



# Cognition, Language and Aging

*Edited by Heather Harris Wright*



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*To Haley and Steve*



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# Cognition, language, and aging

## An introduction

Amy Henderson and Heather Harris Wright

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Age-related changes in cognitive and language functions have been extensively researched over the past half-century. The study of age-related changes has spanned numerous disciplines including linguistics, psychology, gerontology, neuroscience, and communication sciences. The older adult represents a unique population for studying cognition and language because of the many challenges that are presented with investigating this population, including individual differences in education, life experiences, health issues, social identity, as well as gender. The purpose of this book is to provide an advanced text that considers these unique challenges and assembles, in one source, current information regarding cognitive-linguistic processes in the aging population. Providing a comprehensive discussion of language across the adult lifespan by considering neurophysiology, cognition, psycholinguistics, and sociolinguistics offers a stronger foundation for understanding factors that contribute to normal changes in language processes.

As demonstrated in this text and others, cognitive aging is an expansive field of study that involves understanding how cognitive changes normally occur across the adult lifespan. Understanding normal changes is critical for determining pathological as well as exceptional changes (Burke & McKay, 1997; Craik & Salthouse, 2007). Specific to language, changes have primarily focused on word retrieval (e.g., tip-of-the-tongue), sentence comprehension, and discourse. Recently, researchers have also considered the role of psychosocial factors on aging and how these factors may mediate age-related changes in cognitive and linguistic processes and these are discussed in later chapters. Finally, reading ability provides further insight into understanding how cognitive processes change with age and is further addressed in the book. The purpose of this chapter is to orient the reader to the text and overview the many facets of cognition, language, and psychosocial factors in the older adult.

In the second chapter, Abrams and Davis provide an in depth review of the “tip-of-the-tongue” phenomenon a phenomenon that occurs in speakers of all

ages but increases in frequency as a person ages: the tip-of-the-tongue phenomenon. When a person experiences a tip-of-the-tongue event, he cannot access and produce the word that he wishes to despite a strong feeling of knowing what the word is. Studies have shown that when a person experiences this phenomenon, they can often produce part of the word's phonology (e.g. Brown & McNeill, 1966) which adds credence to the idea that on some level, the person 'knows' the word. Two potential explanations are given for tip of the tongue states. One explanation is that a tip-of-the-tongue state occurs when an alternate word comes to mind first and blocks access of the desired word (e.g., Brown, 1979; Jones, 1989; Jones & Langford, 1987; Reason & Lucas, 1984; Roediger, 1974; Woodworth, 1929). The other explanation involves a problem in the transmission through the multiple levels of processing needed for speech production (e.g., Burke et al., 1991; Dell, 1986; Levelt, 1989; but see Caramazza & Miozzo, 1997). According to the inhibition deficit hypothesis (e.g. Zacks & Hasher, 1994), older adults experience more tip of the tongue states than younger adults because inhibitory processes are compromised in older adults which makes it difficult for them to suppress competing alternate words. According to the transmission deficit hypothesis (e.g. MacKay & Burke, 1990), the nodes between the lemma and the word's phonology are weakened in older adults which means that a greater degree of activation is needed to access the word's phonology. After introducing the theories behind what causes a tip of the tongue state, the authors review studies about the factors that increase and decrease the likelihood of a tip of the tongue state occurring as well as the factors that increase or decrease the chance of a tip of the tongue state being resolved. These factors do not always affect old and young adults in the same way and some of these factors can interact. Through considering how these factors affect members of different age groups, the authors help to clarify how changes in the linguistic and cognitive systems lead to the word finding difficulties seen in older adults.

In the third chapter, Marini and Andreetta discuss the different levels of language processing, the age related changes seen in those levels of processing and the neuropsychological changes that can potentially explain the language behaviors seen in older adults. There is evidence that aging affects both micro (intra sentential) and macro (intersentential) linguistic processes. On the microlinguistic level, older adults may experience increased difficulty with word finding (Albert et al., 2009; Griffin & Spieler, 2006; Connor et al., 2004) and grammatical processing (Shadden, 1997). On the macrolinguistic level, older adults may exhibit increased off topic verbosity (Pushkar, Gold, & Arbuckle, 1995), a greater tendency to leave some thoughts unfinished and a decreased ability to use cohesive markers to structurally link successive utterances (e.g. Marini, Boewe, Caltagirone, & Carlomagno, 2005). It is likely that these changes are the result of the interaction of the linguistic

and cognitive systems instead of the linguistic system in isolation and the chapter discusses how working memory, attention and executive control may contribute to these changes. At the end of the chapter, Marini and Andreea discuss neurophysiological changes that occur in older adults and use these changes to make inferences about the mechanisms of language deterioration in older adults. In particular, the role of frontal areas is discussed since these areas are particularly vulnerable to age-induced change. These areas are important for planning, monitoring and inhibiting, which are skills needed to produce a coherent discourse (Marini et al., 2005). Frontal areas have also been implicated in episodic memory encoding (Cabeza, Anderson, Locantore, & McIntosh, 2002) and self-initiated encoding of words (Logan et al., 2002) and would thus be important for message generation. Older adults also show different patterns of brain activation than younger adults while engaging in certain linguistic tasks (e.g., Ghisletta & Lindenberger, 2003; Park et al., 2004). Marini and Andreea close the chapter with a discussion of studies which suggest that these patterns of activation could indicate that older adults are making use of compensatory mechanisms to offset the effect of atrophy and neural changes in certain regions.

How cognitive processes contribute to older adults' language production abilities has also been considered and Kintz and colleagues overview production abilities at the discourse level in Chapter 4. Producing discourse is a cognitively demanding task because it involves more than simply stringing isolated words, propositions, or utterances together. It involves organizing utterances within a framework to produce a narrative, including sufficient information to make the narrative understandable, linking successive utterances together so that the relationship between these utterances can be understood and linking all utterances to the main topic of the discourse. Difficulties in any of these aspects of discourse can burden the listener because when information is left out or presented in a confusing manner, the listener must make inferences and bridge gaps to comprehend the discourse. When evaluating discourse, both micro and macrolinguistic elements should be considered. Microlinguistic skills appear to be more resistant to age-related decline compared to macrolinguistic skills and in particular, lexical diversity, which refers to the range of a person's vocabulary, remains well preserved in older adults (Cooper, 1990; Fergadiotis, Wright, & Capilouto, 2011; Kemper & Sumner, 2001; Kemper, Schmalzried, Hoffman, & Herman, 2010). By contrast, the macrolinguistic process of coherence appears to be vulnerable to age-related declines. Local coherence refers to how meaning is linked between successive utterances and appears to be more resistant to age-related change than global coherence, which is how meaning of the overall discourse topic is maintained across utterances. Maintenance of global coherence is cognitively demanding and age-related

changes in cognitive processes may contribute to the age-related changes in maintenance of global coherence.

In the fifth chapter, the lexical, grammatical, and sensory factors that affect sentence comprehension in older adults are explored. On the lexical level, older adults recognize words more slowly than younger adults (Kliegl, Grabner, Rolfs, & Engbert, 2004; Rayner, Reichle, Stroud, Williams, & Pollatsek, 2006). This is not due to a loss of lexical knowledge since older adults actually show greater vocabulary scores than younger adults. Instead, it is most likely due to general slowed processing which makes words more difficult to access. Additionally, factors such as word frequency, neighborhood phonological density, predictability and presentation speed affect word recognition ability differently in older versus younger adults. Studies that have explored whether or not grammatical complexity exerts different effects on older versus younger adult's ability to comprehend sentences have yielded conflicting results. The chapter presents the results of several sentence comprehension studies, some which do not show a difference in how sentence complexity affects older and younger adults (e.g. Waters & Caplan, 2005) and some which show that older adults experience more difficulty with syntactically complex sentences compared to younger adults. (e.g. Dede, Caplan, Kemetes, & Waters, 2004). The authors argue that, taken together, the results of these studies suggest that older adults do not present with a specific syntactic processing deficit but instead, their ability to comprehend syntactically complex sentences may be affected by age related changes in cognitive abilities. The authors discuss how lower working memory capacity and inefficiency in allocating processing resources may contribute to declines in the ability to comprehend syntactically complex sentences. Finally, the authors discuss how sensory impairments such as reduced visual and auditory acuity may affect sentence comprehension and present evidence which indicates that older adults are disproportionately affected by stimulus degradation compared to younger adults (e.g. Stewart & Wingfield, 2009; Rayner et al., 2010). Overall, due to both cognitive and sensory factors, older adults must work harder by using compensatory techniques to achieve the same level of comprehension as younger adults.

Although older adults experience decline in some language domains, they also retain abilities in some important domains. In the sixth chapter, Copeland, Bies-Hernandez, and Gunawan discuss the ability of older adults to use situation models to comprehend narratives. A situation model is a mental model of an event derived from a narrative. People typically construct three levels of representation upon hearing a narrative (Radvansky, Zwaan, Curiel, & Copeland, 2001). The surface level representation consists of the recall of the words that were actually used. The propositional textbase consists of the event in words but may not retain the exact wording used. Situation models consist of a deeper level of

representation and include both ideas that were directly expressed and the inferences which come from these ideas. After introducing these three levels of memory representation, the authors discuss the cognitive processes of working memory and inhibition within the context of these three levels and age related performance on narrative comprehension. Working memory is more closely related to the surface level and textbase level of representation than to the situation model level and older adults tend to show deficits at the first two levels but not the third. In a recent study Shake, Noh, and Stine-Morrow (2009) showed that while younger adults performed better when memorizing simple facts, older adults performed better with elaborated texts. This is likely due to the fact that although elaborated texts contain a great deal of information, they are presented in an integrated way and thus are not as taxing on working memory as separate pieces of information that are not integrated. Older adults also tend to make more inferences about a text than younger adults and the authors discuss how this could be due to differences in inhibitory processes. This tendency has some positive effects since making inferences allows deep, synthesized processing of a text. However, not all inferences are true or desirable. Older adults have been found to have difficulty suppressing incorrect inferences (Hamm & Hasher, 1992) and may be more vulnerable to making inferences based on stereotypes (Radvansky, Copeland, & von Hippel, 2010). Finally, the authors consider situation models in the context of non-narrative tasks such as syllogism resolution (e.g., Copeland & Radvansky, 2007). Results from these tasks suggest that older adults can effectively construct a single situation model to comprehend and solve a problem but that they have difficulty when a problem requires multiple representations to be managed. This is likely due to their working memory limitations.

Reading is important to older adults and requires coordination of a multitude of processes including cognition, perception, and motor. Gordon, Lowder, and Hoedemaker review age related changes in reading in Chapter 7. Word perception abilities remain relatively intact in older adult readers which is surprising since older adults experience changes in visual acuity and because skilled reading involves the kind of rapid processing of stimuli that is often impaired in older adults. Text memory is also well preserved in older readers despite the fact that other types of episodic memory processes decline in aging. The concepts of surface representations, text based representations and situation models are revisited in this chapter; the ability to construct situation models during comprehension helps older adults remember what they have read later. Age differences in memory for text tend to be much smaller than differences reported using other paradigms (Alexander et al., 2012; Zelinski & Kennison, 2007) and the sentence processing mechanisms needed to build the memory representations of what was read also remain well preserved except for in very complex constructions (e.g., Caplan

et al., 2011; Kemper, 1987; Kemper et al., 2004; Kemper & Liu, 2007; Kemtes & Kemper, 1997). The authors suggest that this points to the inadequacy of working memory models for explaining sentence comprehension and text memory. As an alternative, the authors suggest models which characterize comprehension as to how syntactic, semantic, and pragmatic information is encoded, stored and retrieved during processing (e.g., Gordon & Lowder, 2012; Gordon, Hendrick, & Johnson, 2001; Johnson, Lowder, & Gordon, 2011; Ledoux & Gordon, 2006; Lewis & Vasishth, 2005; Lewis, Vasishth, & Van Dyke, 2006; Van Dyke & Lewis, 2003). The same processes of encoding and retrieval would also underlie text memory. In this sort of memory system, encoding and retrieval are facilitated by meaningful representations supported by multiple cues which would allow older adults to draw on their world experience and experience with language to facilitate comprehension.

Though there are certain cognitive and linguistic declines that are often seen in older adults, one must keep in mind that older adults make up a heterogeneous group. This heterogeneity increases as people live longer lifespans. Chapter 8 explores cognitive and linguistic processes in the “oldest old,” persons who are 90 years old or older. One focus of this chapter is the psychosocial factors that should be considered when studying the oldest old relative to other adults. Since older adulthood includes individuals from age 60 to over 100, there are several different generational cohorts included within this group. The authors argue that generational cohort can affect cognitive and linguistic functioning through many different mechanisms. For example, individuals from different cohorts may not have grown up with the same access to education or may have been educated in different ways. They may have grown up with different health challenges. Technology, culture and language change rapidly. The authors argue that when studying cognition and health in older adults, one should use a lifespan approach and consider the impact of multi-level influences. In addition to exploring the heterogeneity of the oldest old in the context of diverse psychosocial factors, the authors also explore heterogeneity in cognition in this age group. The trajectory of language decline in this age group is not well understood. In this chapter, the challenges of assessment in this age group are discussed as well as the challenges of data interpretation. A greater understanding of the cognitive abilities of the oldest old is vital for two major reasons. First, one needs to understand normative change in order to identify non normative change. Clarifying what normal cognition and linguistic functioning looks like in the oldest old may help us identify early markers for dementia. Second, very old individuals without dementia provide a model for possible resistance to dementia which could mean that they display protective factors which could be of great scientific interest.

In the last chapter, the concept of aging is considered from a sociolinguistics perspective. From this perspective, language is used not only to communicate ideas but to allow an individual to construct his identity. The construct of aging has a performative aspect to it; it is not only determined by chronological age but by an individual using language to establish himself as a member of the aging community. They can establish this identity by using language forms associated with older adults or by making their age salient through the content of their speech. Internet corpora, blogs, and message boards have provided new ways for sociolinguists to study language use in older adults and how members of this group use language to construct identity. When considering how older adults use language to construct identity, one should consider the intersection of age and other identity categories; it has been shown that older adults change their linguistic repertoire as they age especially in variables that index gender and social class (Sankoff & Blondeau, 2007). When studying language variation in older versus younger adults, one must remember to keep in mind the distinction between age grading and ongoing language change (Coulmas & Backhaus, 1999). In age grading, certain linguistic forms are preferred by members of a specific age cohort and these preferences show across successive generations. In ongoing language change, certain forms decrease in younger cohorts because these forms are going out of fashion and being replaced by the entire speech community. Studying older speakers can give us information about genuine language change in addition to information on speech forms associated with aging.

## Summary

Taken together, there are several central themes identified across the chapters. Language behaviors are subserved by both linguistic and cognitive systems and that age-related language decline may not be the result of the degradation of the linguistic system specifically but a result of the interaction between cognitive and linguistic factors. In particular, the cognitive factors of attention, working memory, and executive function are referenced many times and are important for many different language behaviors. Several of the chapters also explore how the interaction of cognitive and sensory factors may affect processing which is important since older adults will experience some degree of sensory decline. Although these chapters report that older adults experience decline in some processes, they also identify processes that are preserved, and how older adults use compensatory strategies to overcome declines in function.

The linguistic system is complex and involves multiple, interacting levels of processing. Different levels of processing require different cognitive and linguistic

demands and aging does not affect all levels of processing in the same way. This text provides a comprehensive look at the specific ways that aging and changes in cognitive processing affect different aspects of language processing: language comprehension, language production, and reading. Because this text is specifically focused on language processing and cognition as it relates to language processing, it provides much more detailed information about the language system than texts which cover cognitive aging in general. This text uses evidence from multiple perspectives (linguistic, psycholinguistic, neurolinguistics) to characterize language processing and use in older adults. Additionally, this text addresses the psychosocial and neurophysiological variables that may account for heterogeneity in both linguistic and cognitive performance that is seen in older adults. By integrating this information, this text provides an overview of both the aspects of language processing that experience age related decline as well as the ones that remain well preserved in older adults.

## References

- Albert, M. L., Spiro, A., Sayers, K. J., Cohen, J. A., Brady, C. B., Goral, M., & Obler, L. K. (2009). Effects of health status on word finding in aging. *Journal of the American Geriatrics Society*, 57, 2300–2305. doi:10.1111/j.1532-5415.2009.02559.x
- Alexander, G. E., Ryan, L., Bowers, D., Foster, T. C., Bizon, J. L., Geldmacher, D. S., & Glisky, E. L. (2012). Characterizing cognitive aging in humans with links to animal models. *Frontiers in Aging Neuroscience*, 4, 1–18. doi:10.3389/fnagi.2012.00021
- Brown, A. S. (1979). Priming effects in semantic retrieval processes. *Journal of Experimental Psychology: Human Learning and Memory*, 5, 65–77. doi:10.1037//0278-7393.5.2.65
- Brown, R., & McNeill, D. (1966). The ‘tip of the tongue’ phenomenon. *Journal of Verbal Learning and Verbal Behavior*, 5, 325–337. doi:10.1016/S0022-5371(66)80040-3
- Burke, D. M., MacKay, D. G., Worthley, J. S., & Wade, E. (1991). On the tip of the tongue: What causes word finding failures in young and older adults? *Journal of Memory and Language*, 30, 542–579. doi:10.1016/0749-596X(91)90026-G
- Cabeza, R., Anderson, N. D., Locantore, J. K., & McIntosh, A. R. (2002). Aging gracefully: compensatory brain activity in high-performing older adults. *Neuroimage* 17, 1394–1402. doi:10.1006/nimg.2002.1280
- Caplan, D., DeDe, G., Waters, G., Michaud, J., & Tripodis, Y. (2011). Effects of age, speed of processing, and working memory on comprehension of sentences with relative clauses. *Psychology and Aging*, 26, 439–450. doi:10.1037/a0021837
- Caramazza, A., & Miozzo, M. (1997). The relation between syntactic and phonological knowledge in lexical access: Evidence from the ‘tip-of-the-tongue’ phenomenon. *Cognition*, 64, 309–343. doi:10.1016/S0010-0277(97)00031-0
- Cooper, P. V. (1990). Discourse production and normal aging: Performance on oral picture description tasks. *Journal of Gerontology*, 45(5), 210–214. doi:10.1093/geronj/45.5.P210

- Copeland, D. E., & Radvansky, G. A. (2007). Aging and integrating spatial mental models. *Psychology and Aging*, 22, 569–579. doi:10.1037/0882-7974.22.3.569
- Coulmas, F., & Backhaus, P. (2009). Introduction: Aging and language. *International Journal of the Society of Language*, 200, 5–10.
- Craik, F. I. M., & Salthouse T. A. (Eds.). (2007). *The handbook of aging and cognition* (3rd ed.). New York, NY: Psychology Press.
- DeDe, G., Caplan, D., Kemtes, K., & Waters, G. S. (2004). The relationship between age, verbal working memory, and language comprehension. *Psychology & Aging*, 19, 601–616. doi:10.1037/0882-7974.19.4.601
- Dell, G. S. (1986). A spreading-activation theory of retrieval in sentence production. *Psychological Review*, 93, 283–321. doi:10.1037//0033-295X.93.3.283
- Fergadiotis, G., & Wright, H. H. (2011). Lexical diversity for adults with and without aphasia across discourse elicitation tasks. *Aphasiology*, 25(11), 1414–1430. doi:10.1080/02687038.2011.603898
- Gordon, P. C., & Lowder, M. W. (2012). Complex sentence processing: A review of theoretical perspectives on the comprehension of relative clauses. *Language and Linguistics Compass*, 6, 403–415. doi:10.1002/lnc3.347
- Gordon, P. C., Hendrick, R., & Johnson, M. (2001). Memory interference during language processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 27, 1411–1423. doi:10.1037/0278-7393.27.6.1411
- Griffin, Z. M., & Spieler, D. H. (2006). Observing the what and when of language production for different age groups by monitoring speakers' eye movements. *Brain and language*, 99(3), 272–288. doi:10.1016/j.bandl.2005.08.003
- Connor, L. T., Spiro, A., Obler, L. K., & Albert, M. L. (2004). Change in object naming ability during adulthood. *The Journals of Gerontology: Series B*, 59(5), 203–209. doi:10.1093/geronb/59.5.P203
- Ghisletta, P., & Lindenberger, U. (2003). Age-based structural dynamics between perceptual speed and knowledge in the Berlin Aging Study: Direct evidence for ability dedifferentiation in old age. *Psychology and Aging*, 18, 696–713. doi:10.1037/0882-7974.18.4.696
- Gold, D. P., & Arbuckle, T. Y. (1995). A longitudinal study of off-target verbosity. *Journal of Gerontology: Psychological Sciences*, 50B, 307–315. doi:10.1093/geronb/50B.6.P307
- Hamm, V. P., & Hasher, L. (1992). Age and the availability of inferences. *Psychology and Aging*, 7, 56–64. doi:10.1037/0882-7974.7.1.56
- Johnson, M. L., Lowder, M. W., & Gordon, P. C. (2011). The sentence-composition effect: Processing of complex sentences depends on the configuration of common noun phrases versus unusual noun phrases. *Journal of Experimental Psychology: General*, 140, 707–724. doi:10.1037/a0024333
- Jones, G. V. (1989). Back to Woodworth: Role of interlopers in the tip-of-the-tongue phenomenon. *Memory and Cognition*, 17, 69–76. doi:10.3758/BF03199558
- Jones, G. V., & Langford, S. (1987). Phonological blocking in the tip of the tongue state. *Cognition*, 26, 115–122. doi:10.1016/0010-0277(87)90027-8
- Kemper, S. (1987). Syntactic complexity and elderly adults' prose recall. *Experimental Aging Research*, 13, 47–52. doi:10.1080/03610738708259299
- Kemper, S., & Liu, C. (2007). Eye movements of young and older adults during reading. *Psychology and Aging*, 22, 84–93. doi:10.1037/0882-7974.22.1.84

- Kemper, S., Crow, A., & Kemtes, K. (2004). Eye-fixation patterns of high- and low-span young and older adults: Down the garden path and back again. *Psychology and Aging, 19*, 157–170. doi:10.1037/0882-7974.19.1.157
- Kemper, S., Schmalzried, R., Hoffman, L., & Herman, R. (2010). Aging and the vulnerability of speech to dual task demands. *Psychology and Aging, 25*(4), 949–962. doi:10.1037/a0020000
- Kemper, S., & Sumner, A. (2001). The structure of verbal abilities in young and old adults. *Psychology and Aging, 16*(2), 312–322. doi:10.1037/0882-7974.16.2.312
- Kemtes, K. A., & Kemper, S. (1997). Younger and older adults' on-line processing of syntactically ambiguous sentences. *Psychology and Aging, 12*, 362–371. doi:10.1037/0882-7974.12.2.362
- Kliegl, R., Grabner, E., Rolfs, M., & Engbert, R. (2004). Length, frequency, and predictability effects of words on eye movements in reading. *European Journal of Cognitive Psychology, 16*(1–2), 262–284. doi:10.1080/09541440340000213
- Ledoux, K., & Gordon, P. C. (2006). Interruption-similarity effects during discourse processing. *Memory, 14*, 789–803. doi:10.1080/09658210600679915
- Levelt, W. M. (1989). *Speaking: From intention to articulation*. Cambridge, MA: The MIT Press.
- Lewis, R. L., & Vasishth, S. (2005). An activation-based model of sentence processing as skilled memory retrieval. *Cognitive Science, 29*, 375–419. doi:10.1207/s15516709cog0000\_25
- Lewis, R. L., Vasishth, S., & Van Dyke, J. A. (2006). Computational principles of working memory in sentence comprehension. *Trends in Cognitive Sciences, 10*, 447–454. doi:10.1016/j.tics.2006.08.007
- Logan, J. M., Sanders, A. L., Snyder, A. Z., Morris, J. C., & Buckner, R. L. (2002). Under-recruitment and nonselective recruitment: Dissociable neural mechanisms associated with aging. *Neuron, 33*, 827–840. doi:10.1016/S0896-6273(02)00612-8
- MacKay, D. G., & Burke, D. M. (1990). Cognition and aging: A theory of new learning and the use of old connections. In T. M. Hess (Ed.), *Aging and cognition: Knowledge organization and utilization* (pp. 213–263). Amsterdam: North-Holland. doi:10.1016/S0166-4115(08)60159-4
- Marini A., Boewe A., Caltagirone, C., & Carlomagno, S. (2005). Age-related differences in the production of textual descriptions. *Journal of Psycholinguistic Research, 34*(5), 439–463. doi:10.1007/s10936-005-6203-z
- Park, D. C., Polk, T. A., Park, R., Minear, M., Savage, A., & Smith, M. R. (2004). Aging reduces neural specialisation in ventral visual cortex. *Proceedings of the National Academy of Science, 101*, 13091–13095. doi:10.1073/pnas.0405148101
- Radvansky, G. A., Copeland, D. E., & von Hippel, W. (2010). Stereotype activation, inhibition, and aging. *Journal of Experimental Social Psychology, 46*, 51–60. doi:10.1016/j.jesp.2009.09.010
- Radvansky, G. A., Zwaan, R. A., Curiel, J. M., & Copeland, D. E. (2001). Situation models and aging. *Psychology and Aging, 16*, 145–160. doi:10.1037/0882-7974.16.1.145
- Rayner, K., Reichle, E., Stroud, M., Williams, C., & Pollatsek, A. (2006). The effect of word frequency, word predictability, and font difficulty on the eye movements of young and older readers. *Psychology and Aging, 21*, 448–465. doi:10.1037/0882-7974.21.3.448
- Reason, J. T., & Lucas, D. (1984). Using cognitive diaries to investigate naturally occurring memory blocks. In J. E. Harris & P. E. Morris (Eds.), *Everyday memory actions and absent-mindedness* (pp. 53–70). London: Academic Press.
- Roediger, H. L. (1974). Inhibiting effects of recall. *Memory and Cognition, 2*, 261–269. doi:10.3758/BF03208993

- Sankoff, G., & Blondeau, H. (2007). Language change across the lifespan: /r/ in Montreal. *Language*, 83, 60–588. doi:10.1353/lan.2007.0106
- Shadden, B. (1997). Discourse behaviours in older adults. *Seminar in Speech and Language*, 18(2), 156–147. doi:10.1055/s-2008-1064069
- Shake, M. C., Noh, S. R., & Stine-Morrow, E. A. L. (2009). Age differences in learning from text: Evidence for functionally distinct text processing systems. *Applied Cognitive Psychology*, 23, 561–578. doi:10.1002/acp.1494
- Stewart, R., & Wingfield, A. (2009). Hearing loss and cognitive effort in older adults' report accuracy for verbal materials. *Journal of the American Academy of Audiology*, 20(2), 147–154. doi:10.3766/jaaa.20.2.7
- Van Dyke, J. A., & Lewis, R. L. (2003). Distinguishing effects of structure and decay on attachment and repair: A cue-based parsing account of recovery from misanalyzed ambiguities. *Journal of Memory and Language*, 49, 285–316. doi:10.1016/S0749-596X(03)00081-0
- Waters, G. S., & Caplan, D. (2005). The relationship between age, processing speed, working memory capacity, and language comprehension. *Memory*, 13, 403–413.
- Woodworth, R. S. (1929). *Psychology* (2nd Rev. ed.). Oxford: Holt.
- Zacks, R. T., & Hasher, L. (1994). Directed ignoring: Inhibitory regulation of working memory. In D. Dagenbach & T. H. Carr (Eds.), *Inhibitory processes in attention, memory, and language* (pp. 241–264). San Diego, CA: Academic Press
- Zelinski, E. M., & Kennison, R. F. (2007). Not your parents' test scores: Cohort reduces psychometric aging effects. *Psychology and Aging*, 22, 546–555. doi:10.1037/0882-7974.22.3.546



# The Tip-of-the-Tongue Phenomenon

## Who, what, and why

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The process of speech production occurs relatively effortlessly, despite complex cognitive processes that underlie word retrieval. However, sometimes these processes do break down and result in a production failure called a tip-of-the-tongue (TOT) state. TOTs are temporary word-finding problems, characterized by an inability to retrieve a word at an intended time despite a strong feeling of knowing the word. TOTs are of particular relevance to older adults, who report having more TOTs and rate them as their most frustrating cognitive failure. The present chapter reviews the relevant literature on age-related changes observed in the TOT phenomenon, with a specific investigation of factors that increase the likelihood of older adults having TOTs as well as those that promote or inhibit TOT resolution. We begin by defining TOTs and their underlying causes in the context of theories of language production. We then discuss empirical findings that examine older adults' disproportionate vulnerability in experiencing TOTs, the ways in which the incidence and resolution of TOTs can be exacerbated or mitigated, the particular susceptibility of proper names to TOTs, and comparisons of healthy older adults with adults with some clinical memory disorders. The chapter concludes with a brief discussion of suggestions for future research directions that may shed light on other unique contributors to these language production failures in old age.

In the course of conversation, almost all speakers, irrespective of variables like age or native language, have experienced a tip-of-the-tongue (TOT) state, which represents a temporary and often frustrating inability to retrieve an intended word (e.g., Burke, MacKay, Worthley, & Wade, 1991; Burke & Shafto, 2004; Gollan, Ferreira, Cera, & Flett, 2014; Gollan, Montoya, & Bonnani, 2005; Miozzo & Caramazza, 1997; Theodoropoulou, Cocks, Pring, & Dipper, 2015). Even people who use sign language, whether hearing-impaired or not, experience language production failures in the form of “tip-of-the-fingers” (Pyers, Gollan, & Emmorey, 2009; Thompson, Emmorey, & Gollan, 2005), and speakers of logographic writing

systems like Chinese can temporarily forget the visual representation of a character, resulting in a “tip-of-the-pen” experience (see Brown, 2012, for a review). The ubiquity of this experience, along with a noticeable increase in TOTs that accompanies normal aging, has made this phenomenon the focus of numerous research studies.

### What is a TOT, and why does it occur?

One of the earliest known references for describing a TOT, without using the term itself, is James (1893), who summarized the experience as follows:

Suppose we try to recall a forgotten name. The state of our consciousness is peculiar. There is a gap therein; but no mere gap. It is a gap that is intensely active. A sort of wraith of the name is in it, beckoning us in a given direction, making us at moments tingle with the sense of our closeness and then letting us sink back without the longed-for term. If wrong names are proposed to us, this singularly definite gap acts immediately so as to negate them. They do not fit the mould. And the gap of one word does not feel like the gap of another, all empty of content as both might seem necessarily to be when described as gaps. (p. 251)

Laboratory research on TOTs did not begin until more than 70 years later, with Brown and McNeill’s (1966) seminal empirical study, where they developed a methodology of inducing TOTs in a laboratory setting. They presented definitions whose answers corresponded to a low-frequency word (e.g., *ambergris*) and asked participants to try and recall the word. Participants who experienced a TOT were asked to record various characteristics of the TOT word, including the number of syllables, first letter, and words with similar sound or meaning. They found that people reported TOTs (360 instances for 56 participants, each of whom heard 49 definitions), which were often accompanied by the retrieval of partial information even when the word itself could not be retrieved. These results documented TOTs as a reliable phenomenon that could effectively be produced in the laboratory and quantified aspects of the TOT state, contributions that were invaluable for subsequent research (see also Brown, 2012, for a historical review).

Early theories about the etiology of TOTs proposed an inhibition explanation, in which TOTs result from a more accessible, alternative word (i.e., interloper) coming to mind first and subsequently blocking retrieval of the intended word (e.g., Brown, 1979; Jones, 1989; Jones & Langford, 1987; Reason & Lucas, 1984; Roediger, 1974; Woodworth, 1929). Some studies provided support for this hypothesis by showing that TOTs could be increased following presentation of a word that was phonologically related (i.e., sharing sounds) to the TOT word. For

example, presentation of the word *dissociation* resulted in more TOTs when participants were trying to retrieve *diminuendo* compared to an unrelated word, such as presenting *opinionated* while attempting to retrieve *cherubic* (e.g., Jones, 1989; Jones & Langford, 1987; see also Maylor, 1990a). However, subsequent research revealed methodological problems with some of these studies (e.g., improper counterbalancing such that questions preceded by a phonologically-related word were more difficult to answer and therefore inherently more prone to TOTs; Meyer & Bock, 1992; Perfect & Hanley, 1992), and ultimately there was little empirical support for blocking as the cause of TOTs.

Alternatively, the cause of TOTs has been specified within theories of speech production. Although theories differ, they generally agree that speakers must complete several stages of processing before articulation of a word begins and results in successful speech production. Specifically, the speaker first chooses the underlying concept to be expressed, then undergoes the process of lexical selection by choosing an abstract word (lemma) that best reflects the concept's meaning and specifies the appropriate syntactic properties, such as its grammatical class. Once selected, the lemma undergoes phonological encoding by transmitting activation to the word's phonology, e.g., syllables and phonemes, so that the word can be articulated. TOTs are thought to involve a breakdown between lexical selection and phonological encoding, where lemma selection was completed successfully, but phonological encoding of the lemma was not (e.g., Burke et al., 1991; Dell, 1986; Levelt, 1989; but see Caramazza & Miozzo, 1997). Retrieval of partial information, as demonstrated by Brown and McNeill (1966), shows that phonological encoding can be partially completed, giving a speaker access to some of the TOT word's phonological information, such as its first letter/phoneme or number of syllables. To produce the word, however, phonological encoding of the lemma must be completed in its entirety.

This breakdown between lexical selection and phonological encoding seems to be exacerbated in old age, evidenced by older adults experiencing more TOTs than young adults, both in self-report diaries and experimental settings (e.g., Brown & Nix, 1996; Burke, Locantore, Austin, & Chae, 2004; Burke et al., 1991; Maylor, 1990b, 1997; Salthouse & Mandell, 2013). In fact, TOTs are often cited as one of the most commonly experienced memory problems, with TOTs for proper names as older adults' most troubling cognitive problem (Cohen & Burke, 1993; Cohen & Faulkner, 1986; Lovelace & Twohig, 1990; Osher, Flegal, & Lustig, 2013; Sunderland, Watts, Baddeley, & Harris, 1986). Understanding *why* TOTs increase with normal aging is important for several reasons. One is that it can help to discriminate between healthy and pathological aging. Knowing what is a "normal" amount of TOTs for a given age range can help us to better understand when older adults' memory failures are typical or whether they may be an indicator of

pathological declines associated with advancing age, such as Alzheimer's disease (AD) or mild cognitive impairment (MCI). In fact, naming difficulties have been identified as among the most functionally debilitating consequences of dementias (Croot, 2009; Gonzalez Rothi et al., 2009; Reilly, Martin, & Grossman, 2005). Another reason is that even in healthy aging, experiencing TOTs has important social consequences. Older adults may withdraw from social interactions if they feel like their TOTs are disrupting conversations or creating a perception of incompetence (e.g., Cohen, 1994; James & Burke, 2000). Thus, an understanding of TOTs is also critical for helping older adults to maintain social and communicative competence.

### Theoretical perspectives of older adults' TOT incidence

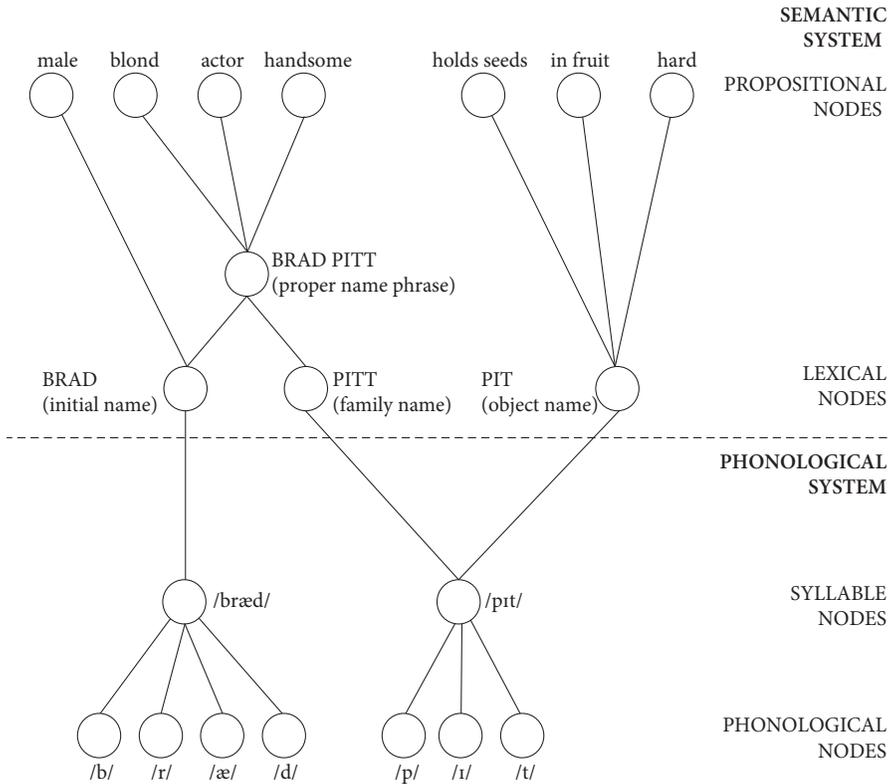
What is it about the aging process specifically that leads to experiencing more TOTs? Two theoretical perspectives have been proposed to explain the higher rate of TOT incidence in older adults: (1) The Transmission Deficit Hypothesis (TDH; e.g., MacKay & Burke, 1990), and (2) The Inhibition Deficit Hypothesis (IDH; e.g., Zacks & Hasher, 1994).

#### Transmission Deficit Hypothesis

Derived from a theory of language production called the Node Structure Theory (MacKay, 1987), the most highly specified explanation of TOTs in old age comes from the TDH. Recall that TOTs are thought to result between the processes of lexical selection and phonological encoding, which are defined within the TDH as individual connections between lemmas and each of their phonological components or nodes. The TDH proposes that there are three specific factors that cause these connections to weaken and experience deficits in the transmission of activation, which result in TOTs (Burke et al., 1991; MacKay & Burke, 1990). One factor is *low frequency of use*, so that infrequently-used words, like those used in Brown and McNeill (1966), are more likely to result in a TOT (see also Burke et al., 1991; Harley & Bown, 1998). Another factor is *nonrecent use*, where words not used or encountered recently, such as the name of one's third grade teacher, are more susceptible to TOTs (e.g., Rastle & Burke, 1996).<sup>1</sup> The most relevant factor for the present discussion is the *normal aging* process: As we age, the

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1. See also Paradis (2004) for a neurolinguistic account of frequency and recency effects in speech production, the Activation Threshold Hypothesis.



**Figure 1.** Representation of proper names and non-names according to TDH (adapted from Burke, Locantore, Austin, & Chae, 2004)

language production system becomes less efficient such that links between all nodes become weakened to some degree.

Although declines in connection integrity are diffusely distributed, the organizational hierarchy of the nodes renders some links more vulnerable to transmission deficits than others (see Figure 1). The retrieval of a given phonological node from the phonological system is particularly susceptible to transmission failures because it is dependent on a single, isolated connection between a word's lexical node (lemma) and its phonology. Consequently, older adults' connections between conceptual information and phonological word forms, which can also be degraded from infrequent and nonrecent use, are particularly susceptible to transmission deficits (e.g., Burke et al., 1991; Burke & Shafto, 2004, 2008; MacKay & Burke, 1990). When the system becomes compromised in this fashion, activation is not easily transmitted across these links, and access to phonology is limited or incomplete, leading to higher TOT incidence for older adults. This explanation

also illustrates why older adults often report little to no phonological information during a TOT in contrast to their young adult counterparts, who frequently remember a few letters or the number of syllables for the nonretrieved word (Brown & Nix, 1996; Burke et al., 1991; Cohen & Faulkner, 1986; Dahlgren, 1998; Maylor, 1990a). In contrast, connections within the semantic system, e.g., between propositional and lexical nodes, are more resistant to age-related transmission deficits because multiple connections (rather than a single one) are involved in activating a lexical node. This structure allows for a convergence of activation upon a lexical node, which can offset age-related transmission deficits in any one semantic-to-lemma connection. Consequently, retrieval of semantic information is less susceptible to age-related declines than retrieval of phonological information (e.g., Mortensen, Meyer, & Humphreys, 2006).

Recent neurophysiological evidence also supports the claim that TOTs result from a deficit at the phonological level (see Díaz, Lindín, Galdo-Álvarez, & Buján, 2014, for a review on neurofunctional correlates), which is further exacerbated by age-related changes in the brain. While they are having TOTs, older adults exhibit reduced activity in the left insula, an important region for phonological production, which is presumed to reflect increased difficulty in retrieving and encoding the appropriate phonology for the target word (Shafto, Stamatakis, Tam, & Tyler, 2010). Likewise, age-related atrophy in this region has been linked to higher TOT incidence (Shafto, Burke, Stamatakis, Tam, & Tyler, 2007). Similar research has investigated the role of the superior longitudinal fasciculus (SLF), an area traditionally associated with phonological processing impairments in developmental dyslexia (Dougherty et al., 2007). When white matter density in the SLF is low, as one would expect from normal neuronal deterioration taking place during the aging process, TOTs occur with greater frequency (Stamatakis, Shafto, Williams, Tam, & Tyler, 2011). Taken together, these findings further support the proposal that an increase in TOTs during old age reflects deficits at the phonological level that prevent successful speech production.

### Inhibition Deficit Hypothesis

An alternative explanation that has been posited to account for age-related declines in word retrieval more generally is the IDH, which emphasizes the importance of inhibitory control for effective speech production. In general, successful goal-oriented behavior is attributable at least in part to our capacity to curb unnecessary or distracting information and focus on the task at hand (e.g., Awh, Matsukura, & Serences, 2003; McClelland & Rumelhart, 1981; Ridderinkhof, Band, & Logan, 1999). The IDH proposes that this ability erodes as we age, leaving us susceptible to a barrage of information competing for our attention (Hasher & Zacks, 1988;

Kane, Hasher, Stoltzfus, Zacks, & Connelly, 1994; Yoon, May, & Hasher, 2000). Although this theory has been used extensively to explore other cognitive impairments such as visual attention or executive function (e.g., Mund, Bell, & Buchner, 2010; Ortega, Gómez-Ariza, Román, & Bajo, 2012), the universality of inhibitory deficits in old age has also been applied to the language production process and TOTs. This hypothesis aligns closely with the cause of TOTs as alternate words that block retrieval, an explanation that might be of greater relevance for older adults; if inhibitory processes are less efficient in old age, older adults who have more TOTs should also be more likely than younger adults to have an alternate word in mind during a TOT, which caused the TOT.

Brown and Nix (1996) supported this prediction, where older adults recorded having more incorrect alternates come to mind during a TOT than young adults, many of which shared partial phonology with the target. However, older adults also reported *less* phonological information during a TOT, which seems inconsistent with the idea that phonologically-similar alternates are causing TOTs. If older adults can activate a similar-sounding alternate's phonology more than younger adults, then they should be able to activate some of the target's phonology as well. A plethora of empirical evidence has emerged to demonstrate that older adults typically produce *fewer* alternates during a TOT compared to young adults, which is more congruent with the interpretation that older adults have a general impairment for retrieving phonological information (Burke et al., 1991; Burke & Shafto, 2004; Fraas et al., 2002; White & Abrams, 2002). However, alternates have been shown to play a role in resolving TOTs for both young and older adults (e.g., Burke et al., 1991; see also Burke & Shafto, 2004, for a review). When TOT states were accompanied by an alternate word, they were less likely to be resolved. Furthermore, even when resolved, retrieving the intended word took longer relative to TOT states that occurred without alternate words in mind, and this delay in TOT resolution was more pronounced for older adults than young adults. Thus, it seems that there are some circumstances under which alternate words can function to compete for retrieval, especially for older adults, but not in general as suggested by the IDH.

## Factors affecting TOT incidence

Examining TOT incidence usually involves manipulating certain characteristics of the target TOT words (e.g., word frequency; Harley & Bown, 1998) or the conditions under which a TOT is elicited (e.g., after a list of phonologically-related words has been presented; James & Burke, 2000). Regardless of the specific manipulation, the aim of experiments investigating TOT incidence is to examine

which factors make TOTs more or less likely to occur. Studies that also include age have attempted to identify which factors have a more pronounced effect on older adults' TOTs. Overall, research on TOT incidence has been illustrative not only in demonstrating the conditions under which speech production processes are prone to failure but also in identifying how the magnitude of these influences change with age. Specific factors that have been studied in conjunction with aging are: (1) word frequency, (2) neighborhood density and frequency, (3) first-syllable frequency, (4) priming of TOT incidence, using phonological primes and semantic primes, and (5) proper name status.

The TDH provides a framework for understanding how these factors might affect TOT incidence by elucidating their impact on a to-be-retrieved target's lemma-to-phonology connections. Specifically, factors that strengthen those connections should decrease TOTs, whereas factors that weaken those connections should increase TOTs. Strengthening/weakening of these connections is directly proportional to the use of the target word's phonology. The factor of word frequency serves as a measure of connection strength such that high-frequency targets have stronger connections, whereas low-frequency targets have weaker connections. The factor of phonological priming involves recent presentation of words containing the target's phonology, which serves to temporarily strengthen the target's lemma-to-phonology connections relative to (a) targets whose phonology was not accessed recently, and (b) semantic primes, words that strengthen the availability of conceptual information. The factor of proper name status in the TDH is represented by names having an additional layer of lemma-to-phonology connections (between a person's full name and each individual name, i.e., first and last name), which makes names more susceptible to TOTs than other types of words.

Connection strength is also influenced indirectly by the phonological relatedness of words associated with a target. Specifically, the factors of neighborhood density, neighborhood frequency, and first-syllable frequency tell us about the number of words that are phonologically connected with a target (i.e., "neighbors"), as well as how frequently those phonologically-related words are used in speech. Because the TDH assumes that activated phonological segments send bottom-up feedback activation back up to all associated lemmas, a target that shares phonological connections with many words and/or high-frequency words consistently receives more bottom-up activation and will consequently have stronger lemma-to-phonology connections, relative to targets that are phonologically related to only a few words and/or low-frequency words. In other words, usage of connections relevant to the target's phonology can influence TOTs for that target.

With respect to aging, MacKay and Burke (1990) proposed that the process of strengthening existing connections is age-invariant, which implies that young and older adults will benefit similarly from factors that strengthen lemma-to-phonology connections. Conversely, older adults' transmission deficits may make them more susceptible than young adults to factors that weaken lemma-to-phonology connections. More generally, the TDH provides an architecture where phonologically-related words can either increase or decrease older adults' TOTs. In contrast, the IDH does not offer a scenario where phonologically-related words will have a facilitative effect for older adults.

### Word frequency

*Word frequency* is a measure of how often a word is used in spoken or written language. In Brown and McNeill (1966), TOTs were elicited by presenting definitions for words with low frequency of use (e.g., *apse*, *nepotism*, *cloaca*, *ambergris*, and *sampan*), as there were anecdotal suggestions that these types of words would be likely to induce TOTs. Theoretical accounts like the TDH also suggest that infrequently-accessed words do not regularly send activation from their lemmas to their associated phonology, thereby making these connections weaker and more susceptible to TOTs. Harley and Bown (1998, Experiment 1) empirically manipulated word frequency by using definition questions whose answers were designated as either high- or low-frequency as categorized by the Oxford Psycholinguistic Database (Quinlan, 1992), a database which contains (among many other psycholinguistic variables) frequency measures that were adopted from an original corpus compiled by Francis and Kucera (1982). As expected, participants in Harley and Bown's experiment were more likely to have TOTs for low-frequency words as opposed to high-frequency words.

Burke et al. (1991, Experiment 1) investigated word frequency naturalistically in a four-week diary study where young and older (mean age 71) participants recorded their TOTs. Resolved TOTs were retroactively categorized in terms of word frequency, using the Francis and Kucera corpus. The median word frequency of TOTs was significantly lower than what would be expected by chance. Furthermore, the majority of reported TOTs (47%, excluding non-normed proper names) in Burke et al. (1991) were words that were so infrequently used that they did not appear in Francis and Kucera's corpus, and a marginal trend indicated that older adults produced slightly more of these "unlisted" words than young adults. This suggested that while low-frequency words are generally more susceptible to TOTs, this might be exacerbated in older adults. These studies converge to support the argument that infrequently used words have inherently fragile connections

between their lemmas and phonology and are therefore more prone to TOTs, an effect that may be compounded by aging.

### Neighborhood density and frequency

Another factor related to TOT incidence is *phonological neighborhood density*, the number of words that phonologically resemble a given target word (e.g., *pint* has phonological neighbors that include words like *pant*, *pine*, and *punts*). Whereas the IDH predicts an inhibitory effect of neighborhood density on TOT incidence because highly dense neighborhoods contain a greater number of potential phonological competitors, the TDH predicts a facilitative effect of high neighborhood density on TOT incidence because of feedback (bottom-up) activation transmitted from neighbors' phonology to associated lemmas. For example, when a target word that has many neighbors becomes activated (e.g., *taper*), its lemma transmits activation to its phonological nodes, which in turn feed activation back to all lemmas that possess some of that phonology (e.g., the lemmas for *tailor*, *tame*, *paper*, etc.). Now those lemmas transmit activation back down to their phonological nodes, which strengthens the shared connections to the target's phonological nodes and makes a TOT less likely to occur. Words with few neighbors receive little feedback activation, making their lemma-to-phonology connections comparatively weak and more vulnerable to TOTs.

Research has supported the TDH's prediction, demonstrating that words with denser neighborhoods are less susceptible to TOTs. Harley and Bown (1998, Experiment 1), who found that low-frequency words induced more TOTs than high-frequency words in young adults, also manipulated neighborhood density, such that within the high- and low-frequency groups, half of the words had high phonological density, and half had low phonological density. Words with lower neighborhood density (fewer phonological neighbors) resulted in more TOTs than those with higher neighborhood density (more phonological neighbors). They also found that neighborhood density interacted with word frequency such that the effect of neighborhood density was greater for low-frequency words than high-frequency words; specifically, low-frequency words that were also low in neighborhood density produced the greatest number of TOTs, which suggests that multiple lexical factors can have an additive effect on increasing TOTs.

Vitevitch and Sommers (2003) used a similar methodology to Harley and Bown (1998), i.e., eliciting TOTs via definition questions (Experiments 1 and 2), but they manipulated *neighborhood frequency* as well as density and compared young and older adults. Neighborhood frequency refers to the mean word frequency of associated phonological neighbors; words with low neighborhood frequency have phonological neighbors that are low in frequency of use on average, whereas

words with high neighborhood frequency have neighbors that are relatively high in frequency. Results from young adults replicated Harley and Bown's (1998) results with respect to word frequency and neighborhood density, but young adults were unaffected by neighborhood frequency. In contrast, older adults' (mean age 70) TOTs were influenced interactively by word frequency, neighborhood density, and neighborhood frequency: Older adults reported more TOTs for words with low neighborhood frequency (compared to words with high neighborhood frequency), but only when the target also had low neighborhood density or low word frequency. Why were older but not young adults affected by neighborhood frequency? Because young adults have stronger connections between lemmas and their phonology than older adults, young adults can receive feedback activation from phonological neighbors regardless of whether those neighbors are high or low frequency. However, older adults can only receive feedback activation from high-frequency phonological neighbors, as connections to low-frequency neighbors are too degraded to provide any feedback (Vitevitch & Sommers, 2003).

### First-syllable frequency

Like neighborhood frequency, a target's *first-syllable frequency* also affects TOT incidence, but again only in older adults (Farrell & Abrams, 2011; but see Gaskell & Dumay, 2003, for related work on the influence of syllable frequency on successful word retrieval in young adults). First-syllable frequency refers to the degree of usage of that particular syllable within the language. A word with high first-syllable frequency possesses a first syllable that occurs in many words (e.g., /dɪ/, as in *decanter*, *deceased*, *debate*, and many others), whereas a word with low first-syllable frequency has a less commonly used first syllable (e.g., /ɒm/ as in *omnivore* and *omniscient*, not many others). Farrell and Abrams examined TOT incidence as a function of target words' first-syllable frequency in three age groups. First-syllable frequency (high or low) was categorized independently from word frequency, as all targets were low-frequency words. Whereas college-aged participants' TOT rates were unaffected by the target's first-syllable frequency, both groups of older adults experienced a first-syllable frequency effect on TOT incidence, with more TOTs occurring for targets with low-frequency first syllables than high-frequency first syllables, and this effect was greater for old-old adults (mean age 80) than young-old adults (mean age 68). This greater influence on first-syllable frequency in older adults also impacted age differences in TOT incidence, such that old-old adults experienced more TOTs than the other groups only when the targets possessed low-frequency first syllables; TOT rates were equivalent for the three groups when targets contained high-frequency first syllables. Because older adults' connections to syllabic representations are weakened, the infrequency

with which low-frequency syllables are produced creates an additive, negative effect for older adults that increases their susceptibility to TOTs, similar to the effects of neighborhood frequency. Conversely, having a large number of words that share a particular syllable offsets the weakening that results from aging, as the higher frequency with which that syllable is encountered strengthens its connections with all lemmas containing that syllable and decreases the likelihood of a TOT occurring (Farrell & Abrams, 2011).

In sum, these experiments on factors described so far indicate that TOTs are not only influenced by certain properties of the TOT word in question (e.g., word frequency) but are also influenced indirectly by other words that are phonologically related to the target. Moreover, it seems that older adults are particularly sensitive to the ways in which these factors interact and influence one another.

### Phonological priming

Because TOTs are presumed to result from a failure to encode the phonology of the correct target word, and also because TOTs are generally more frequent for words that have not been used recently, it is logical to predict within the TDH that strengthening the connections between a word's lemma and phonology will reduce the likelihood that TOTs will occur. Rastle and Burke (1996) systematically tested this assumption by employing a repetition priming procedure, i.e., presenting a target word in an earlier task and then seeing if this recent presentation reinforced the phonological connections for that target and reduced its susceptibility to a future TOT. They exposed young and older adult (mean age 70) participants to a target's phonology by having them read aloud a list of words (the majority of which were nouns, and some of which were proper names) and rate each word for "pronunciation difficulty". Following a ten-minute delay, participants were presented with a set of general knowledge questions, where half of the target answers were words/names read previously (i.e., primed) in the pronunciation task, and they indicated whether they knew the answer, did not know the answer, or were having a TOT. Consistent with prior research, TOTs were more prevalent for older adults, and proper names accounted for the majority of these TOTs. With respect to phonological priming, both age groups experienced a reduction in TOT incidence for targets that were recently produced in the pronunciation task relative to non-recently presented targets, demonstrating priming of TOT incidence as predicted by the TDH.

James and Burke (2000, Experiment 1) also investigated the facilitative effect of strengthening of phonological connections on TOT incidence but conclusively demonstrated that phonological overlap was solely responsible for these effects.

Because Rastle and Burke (1996) had participants produce the identical word prior to administering the TOT-inducing task, their prime overlapped not only phonologically but also lexically and semantically with the target (because they were the same word). James and Burke distributed the phonological segments of each target word over a sequence of prime words that cumulatively contained the target's syllables (e.g., presenting *abstract*, *indigent*, *truncate*, *tradition*, and *locate* when the TOT target was *abdicate*). For each target, young and older adults (mean age 72) were presented with either a primed list (where half of the words shared partial phonology with the intended TOT target word as illustrated above) or an unrelated list of words. After saying each word aloud and rating it for pronunciation difficulty, the general knowledge question was presented, to which participants attempted to retrieve the target. Prior production of the target's phonology, which occurred only when reading primed lists, reduced TOT incidence relative to words in the unprimed lists, and the priming effects were equivalent for both age groups. These findings demonstrate that not only can TOTs be offset by recent presentation of a word's phonology, which presumably strengthens the weakened lemma-to-phonology connections that cause TOTs, but that even older adults can benefit from this exposure.

Burke et al. (2004, Experiment 1) focused specifically on phonological priming of TOT incidence for proper name targets (e.g., *Brad Pitt*), using a picture naming task to induce TOTs. Young and older adults (mean age 72) began each trial by producing the answer to a fill-in-the-blank statement, where the correct answer was either a homophone of the target name (e.g., *pit*) or a non-homophone (e.g., *cane*). After a delay consisting of an intervening filler picture and filler question, the target picture was presented, and participants were instructed to produce the entire name of the person. Prior production of a homophone decreased TOTs for names corresponding to the other spelling of the homophone for both age groups; however, when participants who demonstrated awareness of the phonological relationship between the initial homophone sentence and the target picture were excluded, only older adults exhibited this priming effect. This age-linked asymmetry in phonological priming of TOT incidence, where older adults benefitted *more* than young adults from the strengthening of connections caused by production of the homophone, seems to be linked to older adults' increased difficulty in retrieving proper names relative to object names. The paucity of semantic connections for proper names in conjunction with the age-related weakening of connections allows older adults to benefit more from phonological input, consistent with the claim that aging is a unique and independent factor contributing to retrieval failures.

## Semantic priming

While TOTs reflect a failure to encode the appropriate phonology of a word, individuals generally have sufficient access to semantic (conceptual) information relevant to the intended word (e.g., Burke et al., 1991; Dell, 1986; Levelt, 1989). It is therefore unsurprising that semantic priming has had little effect on TOT incidence. While Rastle and Burke (1996) found advantages for prior processing of phonological information in terms of reducing TOTs, they found that asking participants to first rate how pleasant each of the words were (semantic processing), prior to retrieving them from definition questions, did not provide any extra advantage in reducing TOTs above and beyond simply reading the phonology of the TOT word. Cross and Burke (2004) showed that the lack of facilitation from prior processing of semantic information on TOT incidence also occurred for proper names. In this experiment, young and older adults (mean age 72) were first asked a question about a famous character (e.g., *Eliza Doolittle*), were subsequently shown a picture of the person depicting that famous character (e.g., a picture of *Audrey Hepburn* portraying *Eliza Doolittle*), and were asked to produce the name of the portrayer (e.g., *Audrey Hepburn*). Neither young adults nor older adults experienced a reduction in TOTs, suggesting once again that prior presentation of semantically-relevant information did not strengthen connections between lemmas and phonological information, which are critical for reducing TOTs. Farrell (2012, Experiment 2) compared semantic priming of TOT incidence for both names and nouns. Young and older (mean age 69) participants answered either a prime question containing a word semantically related to the target (e.g., *vegetarian*) or an unrelated question, then attempted to produce the target (e.g., *herbivore*) in response to its question. She found no effect of semantic priming on TOTs for either type of word or for either age group, consistent with the idea that TOTs are linked more strongly to activation of a word's phonology than its semantics. Once again, these effects are contrary to those expected from the perspective of the IDH, which would predict greater interference from semantic competitors, and likewise, more TOTs.

## Name status

The retrieval of proper names has been of particular interest in aging research because names are specifically susceptible to retrieval failures compared to other types of words (e.g., nouns), even for younger adults (e.g., Brédart & Valentine, 1998; Evrard, 2002; Young, Ellis, & Flude, 1988; but see Hanley, 2011; Maylor, 1995, 1997; and Rendell, Castel, & Craik, 2005). Memory for proper names is typically poorer than memory for other descriptive, conceptual information (like

a person's occupation; Barresi, Obler, & Goodglass, 1998), even when a proper name is phonologically identical to a particular descriptor. For example, it is easier to remember that a person *is* a baker than to remember that his name is Mr. Baker (an effect appropriately termed the “Baker-baker” paradox; e.g., Cohen & Faulkner, 1986; McWeeny, Young, Hay, & Ellis, 1987). This disparity for proper names being more difficult to remember than other types of information is even more pronounced in older adults, evidenced by TOTs. Although older adults experience more TOTs than young adults for all types of words, they have disproportionately more TOTs for proper names (e.g., Burke et al., 1991; Cohen & Faulkner, 1986; Evrard, 2002; Farrell, 2012; James, 2004, 2006; Juncos-Rabadán, Facal, Rodríguez, & Pereiro, 2012).

### Explanation for the vulnerability of proper names

What mechanisms are responsible for making proper names specifically susceptible to retrieval failures and for disproportionately impairing their retrieval in old age? A number of possible explanations have been proposed. One possibility is that names have impoverished semantic associations, which make them more difficult to encode in and subsequently retrieve from memory (e.g., Fogler & James, 2007). While non-name nouns (e.g., *dog*) are associated with a global, consistent set of semantic traits by which individuals develop schemas (e.g., a *dog* has fur, four legs, and barks), proper names are associated with a very limited and specific set of semantic criteria that varies from individual to individual (e.g., not every person named *John Smith* will be a lawyer). Anecdotally, we know from our everyday experiences that many people can share a name without necessarily having any features in common. It is likewise difficult to predict what a person is like simply based on their name, except perhaps in the case of nicknames, where a name is derived from a physical feature or personality characteristic (e.g., *negative Nancy*). Without an established semantic network, i.e., a consistent set of factual information, proper names act almost exclusively as meaningless labels that do not provide any substantive information about their associated referent (Brédart & Valentine, 1998; Brédart, Valentine, Calder, & Gassi, 1995; Evrard, 2002; Semenza, 2006, 2009).

This claim can be further illustrated by the Baker-baker paradox. The noun *baker* likely conjures images consistent with its definition, such as someone making bread or other baked goods, wearing a white hat, or covered in flour. These descriptors facilitate and enrich the encoding process, permitting us to more easily integrate the word *baker* into an existing semantic network and making the word easier to retrieve later (e.g., Cohen & Burke, 1993; Cohen & Faulkner, 1986). However, *Mr. Baker* does not evoke any especially descriptive characteristics

(because the name itself is not associated with a specific semantic network), nor does it explicitly relay anything meaningful about the person's profession or image, aside from perhaps suggesting gender and in some cases nationality. Fogler and James (2007) extended the examination of name arbitrariness/descriptiveness to the context of aging, where young and older adults (mean age 71) were presented with pictures of well-known cartoon characters with either descriptive names (e.g., *Snow White*) or non-descriptive names (e.g., *Charlie Brown*). As expected, both young and older adults experienced greater difficulty retrieving non-descriptive names than descriptive names, but older adults experienced significantly more retrieval failures for non-descriptive names than young adults.

In addition to semantic deficiencies, other influences at the lexical or phonological levels may make proper names more difficult to retrieve than other classes of words. For example, proper names (unlike nouns) do not have synonyms that can be used when the target word is temporarily inaccessible (e.g., Brédart, 1993); the terms *insect*, *butterfly*, and *monarch butterfly* can all be used to refer to the same object, whereas there is only one specific name (*Barack Obama*) for the current president of the United States. Because effective production of proper names requires the activation of a single correct name phrase, retrieval failures are not only more likely to occur (as a single deficient connection could lead to a retrieval failure), but it also makes proper name retrieval failures more noticeable because a name cannot be substituted for another word (e.g., James, 2004).

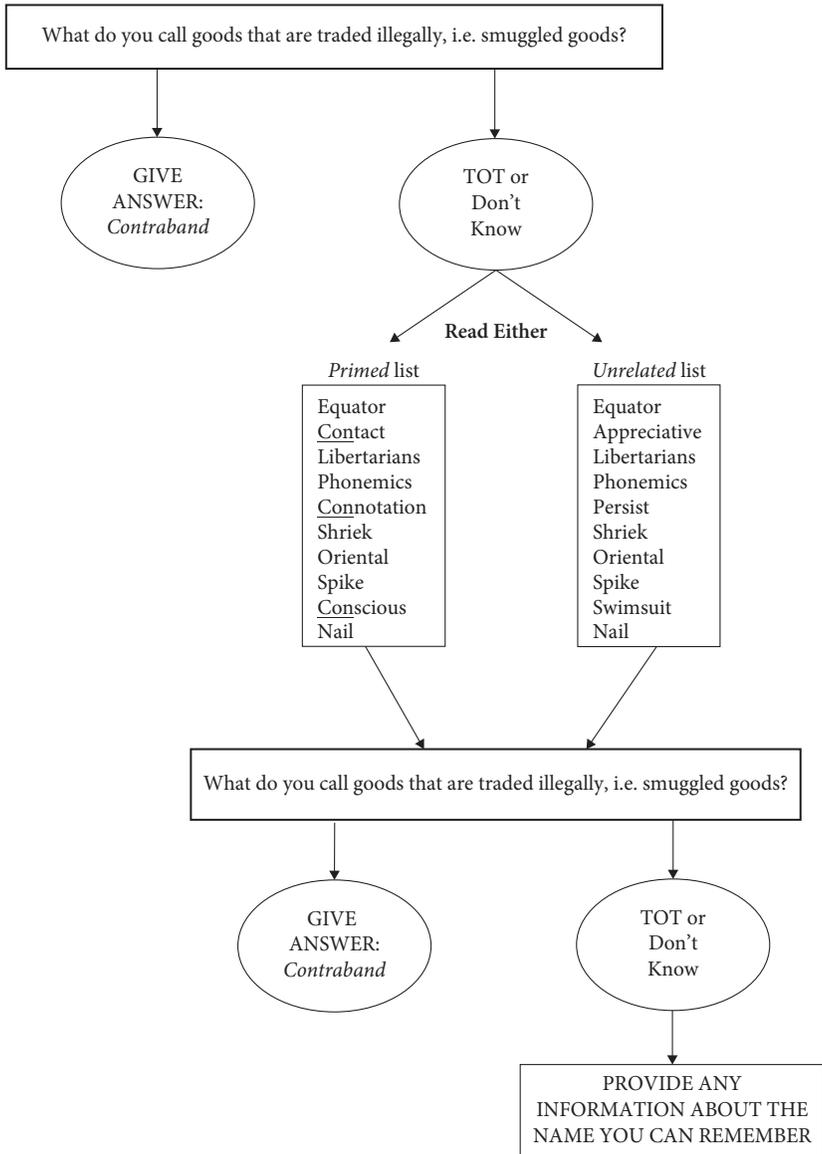
Additionally, proper names typically have multiple phonological components that make up the name phrase (one first name and one last name, and sometimes even a middle name), whereas nouns frequently only have one (see Figure 1). Within the TDH, proper names are associated with increased TOTs because of these additional connections that are susceptible to weakening, i.e., individual connections between the lemma for the full name (*Brad Pitt*) and its corresponding first (*Brad*) and last (*Pitt*) names (e.g., Burke et al., 2004; Burke et al., 1991). When more phonological components are needed to retrieve the entire name phrase, there are correspondingly more opportunities for retrieval failures to occur, which explains why individuals tend to have more TOTs for targets who are known by three names (e.g., actor *Sarah Jessica Parker*) as opposed to just two (e.g., actor *Julia Roberts*; Hanley & Chapman, 2008; Stevenage & Lewis, 2005). Proper names are also generally accessed less frequently than nouns; even the most common names, like *Smith*, are accessed less often than other types of words, which makes the connections among conceptual, lexical, and phonological information within the proper name hierarchy comparatively weak and more prone to retrieval failures (e.g., Burke et al., 1991; Cohen & Burke, 1993; Conley, Burgess, & Hage, 1999).

Taken cumulatively, the evidence presented here suggests that proper names' increased susceptibility to TOTs is due at least in part to the fact that proper names are relatively non-descriptive in nature, do not provide any helpful cues to aid retrieval, and do not fit neatly within a higher semantic network (unlike other types of words). During the natural aging process, opportunities for these already naturally-prevalent retrieval failures become even more frequent because the integrity of the language system is, at baseline, compromised. Further research is needed to understand the degree to which each of these factors contributes independently or additively to older adults' increased TOTs for proper names.

## TOT resolution

Although a considerably smaller literature relative to TOT incidence, the other focus of TOT research has been on the processes that underlie resolution of TOTs, i.e., subsequent retrieval of the intended word after a TOT occurs. The process of resolution can inform us about the weakened lemma-to-phonology connections that cause TOTs because successful resolution of a TOT suggests that these connections, initially weak enough to cause the TOT, have become strengthened, allowing the TOT word's phonology to accumulate a sufficient amount of activation that is necessary for retrieval. The most common method for resolution in people of all age groups is spontaneous resolutions (e.g., Burke et al., 1991; Heine, Ober, & Shenaut, 1999), also called *pop-ups*, where the target word “pops into mind” when not explicitly paying attention to the TOT (Cohen & Faulkner, 1986; Reason & Lucas, 1984). However, older adults typically need more time to resolve their TOTs than younger adults (Burke et al., 1991; Heine et al., 1999; but see Brown & Nix, 1996). Measuring TOT resolution in the laboratory has typically involved a methodology (see Figure 2) where a general knowledge question is presented first. When a TOT occurs, either a primed list (containing words believed to influence resolution) or an unrelated list is shown, after which the TOT-inducing question is shown again. Priming is measured as the difference in TOT resolution following a list containing phonologically-related words relative to a list with solely unrelated words.

Using a priming technique offers a way to provide an alternate word of sorts and assess its effects on TOT resolution. As noted earlier, the presence of an alternate during a TOT delays TOT resolution and decreases the likelihood that the TOT will be resolved (Burke et al., 1991), suggesting that the alternate may be competing with the target for retrieval. Within the IDH, this competition arises from older adults being less able to inhibit the alternate, suggesting that the



**Figure 2.** Example TOT priming resolution methodology (adapted from Abrams, White, & Eitel, 2003). The first syllable in the primed list is underlined for emphasis here

presence of alternate words will be detrimental for TOT resolution under all circumstances. Within the TDH, there are various factors that are likely to affect whether alternates compete with or facilitate TOT resolution, i.e., not all alternates will be competitors for retrieval. Research has explored three such factors

and their interactions with age on TOT resolution: (1) phonological relatedness, (2) grammatical class, and (3) first-syllable frequency.

Phonological relatedness refers to a prime (alternate) that contains some or all of the target's phonology. Similar to its effect on TOT incidence, a phonologically-related prime presented during a TOT should strengthen the lemma-to-phonology connections that caused the TOT and increase resolution, and both young and older adults should benefit similarly. However, phonological priming of TOT resolution may be moderated by the prime's grammatical class. Within the TDH, grammatical class provides a constraint such that only one lexical node, the one accumulating the most activation, can be activated at a time (Burke et al., 1991; MacKay, 1987; MacKay & Burke, 1990). Therefore, having a phonologically-related alternate that is in the same grammatical class as the target should be detrimental to TOT resolution, as the alternate's activation level must subside before the target can be activated. It is possible that older adults will be more adversely affected than young adults by a same-grammatical class alternate and need more time for the target to accumulate sufficient activation, given their weakened connections to phonology. First-syllable frequency, independently and in conjunction with aging, could also play an inhibitory role in TOT resolution within the TDH via competition from interconnected phonological representations. Upon presentation of the prime, its lemma will send activation to its phonological nodes, which in turn will transmit bottom-up activation to the other lemmas sharing that phonology. When there are many other possible lemmas (a high-frequency first syllable), there are more words to compete with the target for retrieval relative to when there are only a few other lemmas (a low-frequency first syllable). Again, the possibility arises that older adults may be particularly susceptible to these proposed first-syllable frequency effects on TOT resolution.

### Phonological relatedness

James and Burke (2000, Experiment 2) were the first to make a causal link between phonological encoding processes and pop-ups. In addition to demonstrating that prior production of phonologically-related words reduces TOT incidence, they also showed that production of words that share phonology with the TOT word increases the likelihood of *resolving* the TOT. For example, after reporting a TOT for *abdicate*, subsequently pronouncing a list of words that included *abstract*, *indigent*, *truncate*, *tradition*, and *locate* resulted in more TOT resolution compared to when a list of unrelated words was presented. Both younger and older adults (mean age 72) exhibited significant priming of TOT resolution. James and Burke interpreted these findings as demonstrating a mechanism by which pop-ups

occur: They are triggered when the TOT word's phonology is perceived or produced, which helps to strengthen the weakened phonological connections that caused the TOT in the first place.

Subsequent research has demonstrated that activating the initial syllable specifically is essential for TOT resolution (Abrams, White, & Eitel, 2003; White & Abrams, 2002). In these studies, the phonologically-related list of words presented during a TOT contained words with solely the first syllable, the middle syllable, the last syllable, or the initial phoneme/letter of the TOT word. TOT resolution was increased only following lists containing the first syllable, suggesting that TOT resolution cannot be facilitated if the TOT word's initial phonology remains unavailable. With respect to age-related differences in priming of TOT resolution, adults in their 60s and early 70s show priming of TOT resolution to the same degree as younger adults (e.g., Heine et al., 1999; James & Burke, 2000; White & Abrams, 2002; but see Abrams, Trunk, & Merrill, 2007). In contrast, adults in their late 70s and 80s have significantly less or no TOT resolution following phonologically-related words (e.g., Abrams et al., 2007; Heine et al., 1999; White & Abrams, 2002). These findings suggest that the severity of transmission deficits that cause TOTs continues to advance with increasing age within older adulthood and affect TOT resolution, similar to increases in TOT incidence (e.g., Heine et al., 1999).

### Grammatical class

Recent research has documented several psycholinguistic factors that are relevant to phonological priming of TOT resolution as well as interactions with age. One such factor is the prime's grammatical class, or part of speech. The relevance of part of speech can be observed in alternate words that sometimes accompany TOTs. Not only do alternates frequently share phonological features such as first letter and number of syllables with the intended target, but they also typically share syntactic features such as part of speech (e.g., Brown & McNeill, 1966; Burke et al., 1991; Miozzo & Caramazza, 1997). For example, in Burke and colleagues' (1991) four-week diary study of TOTs, alternates reported during TOTs were frequently the same part of speech as the target (85% of the time for young adults, 93% for older adults). This overlap with part of speech is interesting, particularly because the presence of alternates has a detrimental effect on TOT resolution in naturalistic studies: When TOTs are accompanied by alternate words, TOTs take longer to resolve and are less likely to be resolved than TOTs that occur without alternates (Burke et al., 1991). Together, these findings suggest that an alternate's grammatical class may be critical in determining when TOT resolution will occur.

Abrams and Rodriguez (2005) tested this idea via phonological priming of TOT resolution and found that a phonological prime's grammatical class plays a pivotal role in influencing TOT resolution in laboratory studies. Following a TOT (e.g., for *rosary*, a noun), participants pronounced aloud a list of words containing either a phonological prime with the same first syllable and same part of speech as the target (e.g., *robot*, which is a noun), a phonological prime with a different part of speech (e.g., *robust*, which is an adjective), or an unrelated word. They found that a phonologically-related word increased TOT resolution only when it was a part of speech different from the target. Phonologically-related words that were the same part of speech as the target had no effect, resulting in similar rates of TOT resolution to that following the unrelated word list.

Interestingly, these influences of grammatical class on TOT resolution were not uniform across the lifespan. Comparing younger adults and two groups of older adults, Abrams and colleagues (2007) found that adults aged 61–73 performed similarly to younger adults, showing phonological priming of TOT resolution only when the prime was a different part of speech from the target, although they exhibited priming to a lesser degree than younger adults, and no priming when the prime was the same part of speech as the target. In contrast, adults aged 75–89 did not get increased TOT resolution from either type of prime, and even more interestingly, they demonstrated an inhibitory effect on TOT resolution following a same part-of-speech prime: Their retrieval of the target was *worse* after reading the list containing the prime compared to the list with unrelated words. These findings suggest another difference that arises with advancing age: Alternates can become more competitive for retrieval during a TOT but only under specific circumstances. What is the possible mechanism that underlies this effect, since it cannot be explained solely by older adults having inefficient inhibitory processes as proposed by the IDH? One possibility is that when the activation level of an alternate approaches or exceeds that of the TOT target, the alternate can become a competitor and delay TOT resolution (see Dell & Gordon, 2003, and Gordon & Kurczek, 2014, for related arguments regarding phonological neighborhood and speech production). The weakened lemma-to-phonology connections for the oldest adults are particularly susceptible, allowing an alternate to become competitive during a TOT, but only when the alternate shares the appropriate phonological and syntactic information of the target.

### First-syllable frequency

Another factor shown to affect TOT resolution in younger and older adults is the target's first-syllable frequency (Farrell & Abrams, 2011). Recall that first-syllable

frequency affected TOT incidence but only for older adults, such that both groups of older adults experienced more TOTs for words with a low-frequency first syllable relative to a high-frequency first syllable. Interestingly, first-syllable frequency had the opposite effect on TOT resolution, and it affected young and older adults similarly. When a phonological prime with the same first syllable as the target was presented during TOTs, all age groups *resolved* more TOTs for targets with a low-frequency first syllable, i.e., having a low-frequency first syllable was beneficial to target retrieval. Farrell and Abrams proposed that this reversal in the effect of first-syllable frequency may be a function of competition that is initiated by the prime word, once in a TOT. The prime's first syllable transmits activation to the other lemmas sharing that syllable, so when there are many other possible lemmas (a high-frequency first syllable), there are more words to compete with the target for retrieval relative to when there are only a few other lemmas (a low-frequency first syllable).

Contrary to the competition created by alternates that share grammatical class (Abrams et al., 2007), the oldest adults in Farrell and Abrams (2011) did not experience greater competition than the other age groups from primes with high-frequency first syllables. One possible explanation is that the frequency of those non-presented competitors also plays a role in TOT resolution. It seems likely that the lemmas associated with a high-frequency first syllable may be higher in word frequency, making them competitive for all age groups because the target words that are susceptible to TOTs are generally low frequency. In any case, research on TOT resolution has demonstrated that there are specific age-linked changes to the utilization of phonological processes and that those changes are not uniform for older adults of all ages.

### Proper name TOTs in Alzheimer's disease

Up to this point, the chapter has focused on the increase in TOTs as a function of normal, healthy aging. However, TOTs have also been a fruitful source of information regarding the progress of certain aspects related to pathological aging. For example, although general language impairments have been reported in a variety of neurodegenerative diseases (e.g., semantic dementia; Reilly & Peele, 2008), proper name retrieval failures have been distinctively and consistently linked to AD and MCI, a pre-AD memory disorder classified by a range of clinical subtypes, which can convert to AD<sup>2</sup> (e.g., Estévez-González et al., 2004; Juncos-

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2. See Fischer et al. (2007) for an empirical comparison between MCI subtypes, and Petersen (2003) for an overview.

Rabadán, Facal, Lojo-Seoanne, & Pereiro, 2013a; Risacher et al., 2009; Semenza, Borgo, Mondini, Pasini, & Sgaramella, 2000; Semenza, Mondini, Borgo, Pasini, & Sgaramella, 2003; Thompson, Graham, Patterson, Sahakian, & Hodges, 2002). Research has attempted to explain proper name retrieval failures in terms of the asymmetric degradation of the brain during the course of AD. Unlike other brain injuries that result from an immediate focal lesion (e.g., stroke), AD has an insidious onset that typically begins with atrophy in the medial temporal lobe (e.g., Barbeau et al., 2008; Barkhof et al., 2007; Jacobs et al., 2011; Visser, Verhey, Hofman, Scheltens, & Jolles, 2002), with the development of neurofibrillary tangles in subhippocampal regions such as the perirhinal and entorhinal cortices that are important for memory retrieval (Delacourte et al., 1999). This early atrophy also extends to anterior temporal regions (McDonald et al., 2009), which together form the *anterior temporal network* (ATN; consisting of the hippocampus, temporal pole, uncus, and the entorhinal/perirhinal cortices; Gour et al., 2011; Kahn et al., 2008), before slowly progressing to more posterior, neocortical regions (see also Braak & Braak, 1991, for a description of Alzheimer's stages). The result is a disease whose symptoms emerge slowly, sometimes unnoticeably, and become progressively more malignant and apparent (e.g., Longley & Warner, 2002).

The fact that AD seems to initially target regions in the ATN is particularly relevant for the retrieval of proper names, as some recent research indicates that the left anterior temporal regions (namely, the temporal pole) may be more involved with storage and retrieval of proper names compared to other types of words (Damasio, Grabowski, Tranel, Hichwa, & Damasio, 1996; Gorno-Tempini et al., 1998; Semenza, 2011). Specifically, it has been suggested that the temporal pole helps to mediate *phonological* retrieval processes necessary for name articulation in conjunction with other perisylvian structures (e.g., Damasio & Damasio, 1994; Juncos-Rabadán et al., 2011; Proverbio, Lilli, Semenza, & Zani, 2001). The temporal pole has also been suggested to be involved with the retrieval of person-specific *semantic* information (Brambati, Benoit, Monetta, Belleville, & Joubert, 2010), supported by connections to medial structures that are important for memory retrieval like the entorhinal cortex and hippocampus (Arnold, Hyman, & Van Hoesen, 1994; Ding, Van Hoesen, Cassell, & Poremba, 2009; Guedj et al., 2010; Juncos-Rabadán, Rodríguez, Facal, Cuba, & Pereiro, 2011; Muñoz & Insausti, 2004; Vorobyov & Brown, 2008). Alternatively, storage and retrieval of other types of words may rely on a more distributed neural network (Proverbio et al., 2001; Warburton et al., 1996; see also Martin, 2007, for a review), which may not be so locally impacted in early AD. Thus, it follows that pathological degradation to these parts of the anterior and medial temporal regions may specifically hinder proper name retrieval in AD, compared to the retrieval of other types of words (e.g., Semenza et al., 2003). In the following sections, we will examine

research that demonstrates how AD increases the likelihood of proper name TOTs, both in terms of increasing transmission deficits during phonological retrieval and, more gradually, reducing access to relevant semantic information.

When examining phonological access impairments experienced by multidomain MCI patients, Juncos-Rabadán and colleagues (2011) eloquently described the role of the temporal pole as “a mediational structure that is engaged by those structures that guide the implementation of process of phonological representation in vocalization (supported by left temporal perisylvian language areas)” (p. 650). The fact that the anterior temporal lobe/temporal pole is considered to be at least partially involved in proper name phonological retrieval is notable because it interfaces with what is already known about the cognitive mechanisms of proper name TOTs: Age-related decline contributes to a weakening of the connections between proper name lemmas and associated phonological nodes. However, the atrophy resulting from AD is far more severe than the gradual neuronal degradation that would be expected during the normal aging process, even in early or moderate stages of the disease (e.g., Jack et al., 1997; Jacobs et al., 2011). From the perspective of the TDH, this has been interpreted to mean that the connections between lemmas and phonological nodes in AD patients are significantly more degraded than those in healthy older adults (e.g., Juncos-Rabadán et al., 2011). This helps to explain why AD patients report more proper name TOTs than healthy older adult controls, and also why these TOTs become more prevalent as atrophy spreads and the brain becomes increasingly deteriorated (e.g., Delazer et al., 2003; Juncos-Rabadán et al., 2013a; Juncos-Rabadán, Facal, Logo-Seoane, & Pereiro, 2013b; Juncos-Rabadán et al., 2011).

Some behavioral research has extended these claims of disproportionately impaired phonological access in AD by examining the amount of phonological information that AD patients have available during a proper name TOT. For example, a celebrity face-naming study by Delazer and colleagues (2003) found that relative to healthy controls (mean age 72) and high-functioning older adults with MCI, AD patients (mean age 73) were less likely to provide pertinent phonological information (e.g., first phoneme or syllable) during a TOT when probed, and they also did not benefit as much from phonological cuing (i.e., retrieving the name after partial phonology was supplied). Overall, evidence seems to suggest that the increase in proper name TOTs for AD patients is at least partly related to severely compromised connections between lemmas and associated phonological nodes, exaggerated by disproportionate atrophy in the temporal regions of the brain.

Furthermore, the fact that the anterior temporal lobe/temporal pole is considered to be involved in proper name retrieval introduces another important factor that distinguishes healthy older adults from AD patients: Disproportionate

impairments in retrieving semantic information related to proper names. For example, in a fMRI study, Brambati and colleagues (2010) asked participants to classify individuals based on occupation and found that the anterior temporal lobe was indeed involved with retrieving person-specific semantic information. Behavioral research (e.g., Delazer et al., 2003; Hodges, Salmon, & Butters, 1993) has complemented these fMRI data, demonstrating that AD patients produce significantly less biographical information (e.g., details relating to a person's occupation) relative to healthy older adult controls, possibly as a result of decreased integrity of regions in the ATN network. This is a fairly idiosyncratic symptom of AD because, as previously mentioned, healthy older adults are generally able to produce sufficient semantic information when experiencing proper name TOTs (e.g., Cohen & Faulkner, 1986). To examine this disparity, Beeson, Holland, and Murray (1997) compared adults suffering from mild AD (mean age 78), moderate AD (mean age 76), and healthy older adults suffering only from linguistic impairments (various forms of aphasia, with otherwise intact memory; mean age range 61–72) on proper name TOT incidence using a celebrity face-naming task. They found that when asked to produce biographical information during TOTs, all AD patients demonstrated a semantic deficit by producing less biographical information (e.g., the person's occupation) than older adults without AD, with the greatest deficit for the moderate AD group. Even when AD patients produced semantic information, it was less rich and detailed than healthy older adults (e.g., describing Bing Crosby as dead as opposed to a more distinct characteristic, like singer). Similarly, Delazer and colleagues (2003) found that during a TOT, AD patients produced significantly less biographical information in response to semantic questions about celebrity faces (e.g., *What was the profession of this person before he became very famous?*) than healthy controls or high-functioning adults with MCI, who did not differ.

Why are results about semantic retrieval relevant to proper name TOTs in AD? Recall that within the TDH, semantic access is relatively preserved in healthy aging because of an architecture where multiple semantic nodes can converge to activate a lemma and offset transmission deficits in any one connection (e.g., Burke et al., 1991; MacKay & Burke, 1990). As semantic information begins to erode in AD from disease-related anterior and medial temporal atrophy, the once-resilient architecture of the semantic system becomes damaged such that fewer semantic nodes become activated to converge on a specific lemma (e.g., Astell & Harley, 1996). This theoretical explanation would also suggest that top-down transmission of activation from conceptual to phonological levels is generally less effective (e.g., Greene & Hodges, 1996), meaning TOTs are more likely to occur. Thus, although semantic deficits for proper names might not emerge in the earliest stages, such deficits are certainly a hallmark symptom of AD that becomes

quite distinctive as the disease progresses. These deficits are also a relevant factor in influencing proper name TOT incidence in AD.

### Discriminating normal from pathological decline

Knowing that effects of both semantics and phonology influence TOTs in AD is helpful in gauging the long-term trajectory of memory decline, but the question still remains: Is there a way to efficaciously discriminate the point at which proper name retrieval failures are no longer due to normal age-related decline, but rather, *early* stages of AD? Intuitively, it would seem that measuring participants' access to phonological information may be the most informative early diagnostic measure because semantic deficits sometimes become evident only after the disease has become advanced. Research investigating proper name retrievals for older adults with MCI, who are sometimes at risk of developing AD, has proven to be a crucial source of valuable information for addressing this question. Whereas Delazer and colleagues (2003) did not find any differences in phonological access for MCI and healthy control groups during TOTs, they acknowledged that the MCI groups were very high-functioning (only differing from controls in one measure, verbal memory) and were primarily classified on the basis of self-reported memory problems, which might have been prone to bias. In a later experiment, Juncos-Rabadán et al. (2011) compared healthy older adults<sup>3</sup> with normal cognitive functioning to older adults with MCI (whose condition was not self-reported but instead confirmed via neuropsychological tests, like the Mini-Mental Status Exam; Folstein, Folstein, & McHugh, 1975) who had moderate cognitive deficits (consisting of two subgroups, multidomain amnesic and amnesic; mean age 71 and 68, respectively). They demonstrated that one subgroup of adults with MCI (multidomain amnesic) experienced more proper name TOTs in a face-naming task in addition to reduced access to phonological information during a TOT, but had sufficient access to semantic information like healthy controls (e.g., they were able to produce biographical information about the TOT target when asked).

These results were replicated in a second study by Juncos-Rabadán and colleagues (2013a), who followed up two years later with the same tasks and similar clinical populations (multidomain and single-domain amnesic patients, who were combined into a single MCI group), and then again in a third study (2013b) that included slightly different MCI clinical populations (multidomain amnesic

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3. Healthy older adults were split into two groups based on subjective complaints about memory: those with low memory complaints (mean age 68) and those with high memory complaints (mean age 67). The two groups exhibited equivalent functioning on all tasks and are combined together here for simplicity.

and nonamnesic). In each study, the MCI groups consistently exhibited greater phonological retrieval difficulties relative to healthy control populations while experiencing TOTs. Furthermore, there were no differences between multidomain amnesic and nonamnesic groups, as both were equally poor at retrieving phonological information during a TOT. Juncos-Rabadán and colleagues (2013a, 2013b) interpreted these results to suggest that disproportionate phonological deficits may be the earliest signs of neurodegenerative decline, resulting from reductions in cognitive resources and functioning needed to successfully retrieve phonology. Degraded access to phonology is followed later by additive deterioration of semantic access in the progression to AD. Therefore, the first steps in distinguishing healthy controls from MCI (and possibly early stages of other neurodegenerative diseases) might be to establish a threshold for “healthy” access to phonological information in order to confront potential diseases as early as possible, in addition to other classical measures that are employed to detect a decline in cognitive functioning (e.g., attention, executive function/working memory, etc.).

Extant research comparing AD patients and healthy aging adults has been critical in making progress toward defining a specific threshold of proper name retrieval failures that can be used for early detection. Because proper names are firstly and most noticeably affected in AD, more so than in healthy aging, diagnostic batteries might benefit by including proper names retrieval failures in some way as a potential first indicator of pathological decline (instead of only including nouns, which are not a very sensitive early indicator of AD; e.g., Semenza et al., 2003). While a few new cognitive tests have been developed to include proper names as a diagnostic tool for such neurodegenerative diseases (e.g., the *Memory for Proper Names* task; Brouillette et al., 2011), these tasks primarily observe naming accuracy and retrieval of biographical information, not TOT rates, despite how useful proper name TOTs might be as diagnostic criteria. However, it should be acknowledged that there are considerable difficulties to overcome in devising a clinical tool to test proper name TOT incidence, not the least of which is controlling for familiarity of the TOT questions; whereas familiarity with nouns, adjectives, or verbs are maintained across multiple generations, proper names are subject to fluctuating popularity even within a single cohort. Additional constructs would be necessary to verify knowledge of the proper names, and the TOT battery would almost certainly require frequent revisions.

In addition to aiding early diagnosis of AD, there is still much to explore to fully understand the nuances of proper name TOTs as a function of neurocognitive decline. Expanding research on healthy age-related changes in lexical retrieval and TOTs is still necessary for establishing a comprehensive, normative baseline of impairment, which can then be used as a model to identify early signs of pathologically-induced cognitive decline. Furthermore, research still needs to

more finely discriminate symptoms between different types of neurodegenerative diseases. Even though AD is the most common form of dementia (NINDS, 2013), there are also several other types of dementia with differing etiologies and symptoms (e.g., Parkinson's disease, frontal variant dementia, semantic dementia, and MCI; see Reilly, Troche, & Grossman, 2011, for a review). Future research would benefit from understanding how/if language impairments, such as proper name retrieval failures, in each of these diseases uniquely differ from healthy adults, which will aid in early and appropriate diagnosis.

### Current and future directions

Some researchers have highlighted the importance of using appropriate methodological and/or statistical controls before drawing conclusions about age differences in TOTs (Bahrck, Hall, & Baker, 2013; Gollan & Brown, 2006). Gollan and Brown (2006) proposed a new method for calculating TOT incidence that accounts for retrieval failures at different stages: (1) "Step 1" failures, which are failures to activate the target word's lemma (and thus no opportunity to experience a TOT), and (2) "Step 2" failures, which are failures to activate the target's phonological representations after successful lemma activation, i.e., TOTs. They argued that TOTs should be calculated as the number of Step 2 failures divided by the number of Step 1 successes, a proportion that indicates the likelihood of a TOT under conditions where a TOT was possible. With respect to aging, they proposed that these calculations more appropriately take into account older adults' greater experience with words, which results in more opportunities for TOTs to occur, specifically for difficult words.

Bahrck, Hall, and Baker (2013) proposed that age comparisons in recall must first equate the availability of content, i.e., determine which information is equivalently recognizable by both age groups. They developed the accessibility/availability ratio, which provides an estimate of the proportion of available (recognized) memory targets that are also accessible (recalled), and they computed this ratio for younger and older adults' recall of famous names and low-frequency vocabulary words. Using this ratio, they found that only names, not vocabulary words, were more difficult to retrieve for older than younger adults. These findings are not a result of age differences in familiarity with those names (as measured by recognition on a multiple-choice test), which was controlled. Thus, name recall is disproportionately affected in aging, and future research should continue to document factors that can help to reduce or minimize this disproportionate age impairment.

Farrell (2012) discovered one such factor specific to TOT incidence: first syllable frequency. Younger and older adults read general knowledge questions whose target answers were famous names or low-frequency nouns, both of which had first syllables that were categorized either as high- or low-frequency. Consistent with older adults having greater impairment in name retrieval, older adults had more TOTs than young adults for both types of targets, but this age difference was greater for proper names than nouns. However, this disproportionate age deficit occurred only when targets had high-frequency first syllables. For targets with low-frequency first syllables, the age difference were similar for proper names and nouns. These patterns of findings remained when comparing a subset of names and nouns that possessed the identical first syllable, eliminating the possibility that names and nouns having different first syllables contributed to these findings. The other interesting finding was that only older adults demonstrated opposing influences of syllable frequency, where targets with high-frequency first syllables (compared to low-frequency first syllables) resulted in fewer TOTs for nouns but *more* TOTs for names. This influence of high first syllable frequency having a negative effect on production is unique, suggesting that for older adults, having many phonologically-related options can create interference or competition with the target when attempting to retrieve names specifically. Phonologically-related names can all be possible candidates for production (is it *Jennifer*, *Jessica*, *Jenna*?), so having multiple name options that sound like the target's first name becomes more problematic with age. In contrast, phonologically-related nouns typically are not viable candidates and thus do not interfere (e.g., *bunny* and *bus* possess unique semantic properties that make them inappropriate choices when attempting to produce *butter*).

A new direction for future research is the role of semantic priming on older adults' TOT resolution. Whereas there is little evidence of semantic priming effects on TOT incidence, as discussed earlier, there is some evidence from young adults that semantic relatedness can reduce the facilitative effect of phonological priming on TOT resolution for names. White, Abrams, and Frame (2013) examined the effect of semantic relatedness between primes and targets on phonological priming of younger adults' TOT resolution for famous names. They presented questions whose answers were proper names, and TOT responses were followed by another question that contained either a prime name or an unrelated name. Primes were either semantically related (in the same occupation as the target) or unrelated. Primes were also phonologically related by sharing either the target's first name or the first syllable of the first name. The TOT question was presented again, and TOT resolution occurred if the target name could now be retrieved. The results showed that when a prime shared the first name with a target, it facilitated TOT resolution regardless of whether it was semantically related or unrelated.

In contrast, when the prime contained some but not entire phonological overlap with the target's first name (first syllable only), semantically-unrelated primes increased TOT resolution, but semantically-related primes did not.

Although White et al. (2013) did not compare names with nouns, there are relatively few nouns that share both semantic and phonological characteristics. If names are more likely than nouns to have semantic overlap along with partial phonological overlap, conditions that impede TOT resolution, then this could contribute to names being more difficult to retrieve than nouns in everyday life. Additionally, the finding that semantic relatedness between primes and targets can interfere with phonological priming of TOT resolution could have interesting implications for older adults. For example, one possibility is that the oldest adults would experience inhibitory effects on TOT resolution from phonological primes that share semantic category, similar to that observed from grammatical class (Abrams et al., 2007), resulting in a reduction in TOT resolution relative to unrelated names. Older adults are thought to have enriched semantic networks (e.g., Laver & Burke, 1993; Light & Burke, 1993; Taylor & Burke, 2002), which could potentially make them more susceptible to competition from semantically-related prime names that also share first syllable.

Lastly, the effects of non-cognitive influences on TOTs, such as stress or emotion, and their interactions with aging are virtually unexplored. A link between stress and TOTs has been informally suggested via anecdotal evidence (Cohen & Faulkner, 1986; see also Brown, 1991; and Schwartz, 2002), where TOTs are thought to be more likely to occur when a person is under stress. James, Schmank, and Castro (2013) have empirically demonstrated this relationship in college student participants by putting them in a high- or low-stress situation involving preparation of a speech, a modified Trier Social Stress Test. In the high-stress condition, participants prepared a five-minute speech regarding a job interview and then gave the speech with the belief that they were being analyzed by an expert watching them through a one-way mirror. In the low-stress condition, participants also prepared and gave a speech, but the topic was a favorite vacation spot, and they gave the speech without an observer. After a brief intervening period of mental arithmetic, participants were given the TOT questions and attempted to retrieve the answers. The results showed that participants experienced more TOTs in the high-stress condition than in the low-stress condition, suggesting that situational stress in close proximity to word retrieval is detrimental. An interesting question is whether older adults, who may be generally more anxious about having memory failures (e.g., Cohen & Faulkner, 1986; Pearman & Storandt, 2004; Ryan, Kwong See, Meneer, & Trovato, 1992), are particularly susceptible to the effects of stress on TOTs.

A few studies have examined the effect of emotion on TOTs in young adults, where emotion was elicited through the general knowledge questions presented to elicit TOTs (d'Angelo & Humphreys, 2012; Schwartz, 2010). Specifically, emotion was defined in terms of “uncomfortable questions, related to topics likely to be considered negative”, such as “What is the term for ritual suicide in Japan?” (answer: *seppuku*). Schwartz (2010) compared emotion-inducing questions with neutral questions in terms of their likelihood of inducing TOTs, and he reported that more TOTs occurred for emotion-inducing questions than for neutral questions. He also reported a carryover effect such that higher TOT rates also occurred on the next question following an emotion-inducing question. However, these results were challenged by d'Angelo and Humphreys (2012). They determined that in the Schwartz (2010) experiment, the targets corresponding to emotion-inducing questions were lower in word frequency and had fewer phonological neighbors than targets corresponding to neutral questions, variables that increase TOTs (Burke et al., 1991; Harley & Bown, 1998). After controlling for these differences, d'Angelo and Humphrey failed to replicate Schwartz's findings of an effect of emotion on TOTs, so the link between emotion and TOTs remains unclear.

It is also worth noting that emotion defined by the to-be-retrieved word is quite different from the emotion inherently experienced within the person, the latter of which can be observed in older adults' self-reports of TOTs as their most annoying cognitive failure (Lovelace & Twohig, 1990). However, older adults may be better able to manage the emotional arousal that seems to accompany their TOTs. Research has been converging on the idea that older adults have superior emotion-regulation skills (e.g., Carstensen, Isaacowitz, & Charles, 1999; Mather & Knight, 2005) relative to younger adults, evidenced by older adults having greater confidence in their ability to manage their emotions (e.g., Gross et al., 1997; Kessler & Staudinger, 2009; Lawton, Kleban, Rajagopal, & Dean, 1992) and lower levels of physiological arousal in response to some emotional situations (e.g., Labouvie-Vief, Lumley, Jain, & Heinze, 2003; Levenson, Carstensen, Friesen, & Ekman, 1991; Tsai, Levenson, & Carstensen, 2000). Furthermore, older adults attend to and remember proportionally more positive information than negative information (the positivity effect; e.g., Charles, Mather, & Carstensen, 2003; Gröhn, Scheibe, & Baltes, 2007; see also Scheibe & Carstensen, 2010, for a review), an effect thought to stem from an enhanced ability to inhibit negative information (Mather & Knight, 2005). Thus, it remains to be seen whether older adults' enhanced emotion regulation skills can offset the effect of emotional state or arousal on a task involving speech production.

## Conclusion

The awareness that TOTs increase with age is only a starting point for understanding the complex issues that underlie why this phenomenon occurs. While this change is a normal part of the healthy aging process and can be differentiated from retrieval problems that accompany neurodegenerative diseases, it nonetheless remains a frustrating and potentially socially-isolating annoyance of which older adults are consciously aware. As this chapter demonstrates, language production processes are subject to a variety of influences, many of which capitalize on normal age-related decline to disproportionately increase TOT incidence and reduce TOT resolution for older adults. It has yet to be determined whether it is more fruitful for researchers to focus on ways of mitigating older adults' TOTs in the first place or to hone in on strategies that increase their resolution of TOTs. However, it is clear that the first step is developing a comprehensive, theoretical understanding of these retrieval failures and the factors that account for increased susceptibility during the aging process.

## References

- Abrams, L., & Rodriguez, E. L. (2005). Syntactic class influences phonological priming of tip-of-the-tongue resolution. *Psychonomic Bulletin and Review*, 12, 1018–1023. doi:10.3758/BF03206437
- Abrams, L., Trunk, D. L., & Merrill, L. A. (2007). Why a superman cannot help a tsunami: Activation of grammatical class influences resolution of young and older adults' tip-of-the-tongue states. *Psychology and Aging*, 22, 835–845. doi:10.1037/0882-7974.22.4.835
- Abrams, L., White, K. K., & Eitel, S. (2003). Isolating phonological components that increase tip-of-the-tongue resolution. *Memory and Cognition*, 31, 1153–1162. doi:10.3758/BF03195798
- Arnold, S. E., Hyman, B. T., & Van Hoesen, G. W. (1994). Neuropathologic changes of the temporal pole in Alzheimer's disease and Pick's disease. *Archives of Neurology*, 51, 145–150. doi:10.1001/archneur.1994.00540140051014
- Astell, A. J., & Harley, T. A. (1996). Tip-of-the-tongue states and lexical access in dementia. *Brain and Language*, 54, 196–215. doi:10.1006/brln.1996.0071
- Awh, E., Matsukura, M., & Serences, J. (2003). Top-down control over biased competition during covert orienting. *Journal of Experimental Psychology: Human Perception and Performance*, 29, 52–63. doi:10.1037//0096-1523.29.1.52
- Bahrack, H. P., Hall, L. K., & Baker, M. K. (2013). *Life-span maintenance of knowledge*. New York, NY: Psychology Press.
- Barbeau, E. J., Ranjeva, J. P., Didic, M., Confort-Gouny, S., Felician, O., Soulier, E., & ... Poncet, M. (2008). Profile of memory impairment and gray matter loss in amnesic mild cognitive impairment. *Neuropsychologia*, 46, 1009–1019. doi:10.1016/j.neuropsychologia.2007.11.019

- Barkhof, F. F., Polvikoski, T. M., van Straaten, E. W., Kalaria, R. N., Sulkava, R. R., Aronen, H. ... & Erkinjuntti, T. T. (2007). The significance of medial temporal lobe atrophy: A post-mortem MRI study in the very old. *Neurology*, 69, 1521–1527. doi:10.1212/01.wnl.0000277459.83543.99
- Barresi, B. A., Obler, L. K., & Goodglass, H. (1998). Dissociation between proper name and common noun learning. *Brain and Cognition*, 37, 21–23.
- Beeson, P. M., Holland, A. L., & Murray, L. L. (1997). Naming famous people: An examination of tip-of-the-tongue phenomena in aphasia and Alzheimer's disease. *Aphasiology*, 11, 323–336. doi:10.1080/02687039708248474
- Braak, H. & Braak, E. (1991). Neuropathological staging of Alzheimer-related changes. *Acta Neuropathologica*, 82, 239–259. doi:10.1007/BF00308809
- Brambati, S., Benoit, S., Monetta, L., Belleville, S., & Joubert, S. (2010). The role of the left anterior temporal lobe in the semantic processing of famous faces. *Neuroimage*, 53, 674–681. doi:10.1016/j.neuroimage.2010.06.045
- Brédard, S. (1993). Retrieval failures in face naming. In G. Cohen & D. M. Burke (Eds.), *Memory for proper names* (pp. 351–366). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Brédard, S., & Valentine, T. (1998). Descriptiveness and proper name retrieval. *Memory*, 6, 199–206. doi:10.1080/741942072
- Brédard, S., Valentine, T., Calder, A., & Gassi, L. (1995). An interactive activation model of face naming. *The Quarterly Journal of Experimental Psychology: Human Experimental Psychology*, 48A, 466–486. doi:10.1080/14640749508401400
- Brouillette, R. M., Martin, C. K., Correa, J. B., Davis, A. B., Han, H., Johnson, W. D., Foil, H.C., Hymel, A., & Keller, J. N. (2011). Memory for names test provides a useful confrontational naming task for aging and continuum of dementia. *Journal of Alzheimer's Disease*, 23, 665–671. doi:10.3233/JAD-2011-101455
- Brown, A. S. (1991). The tip of the tongue experience: A review and evaluation. *Psychological Bulletin*, 10, 204–223. doi:10.1037/0033-2909.109.2.204
- Brown, A. S., & Nix, L. A. (1996). Age-related changes in the tip-of-the-tongue experience. *The American Journal of Psychology*, 109, 79–91. doi:10.2307/1422928
- Brown, A. S. (1979). Priming effects in semantic retrieval processes. *Journal of Experimental Psychology: Human Learning and Memory*, 5, 65–77. doi:10.1037//0278-7393.5.2.65
- Brown, A. S. (2012). *The tip of the tongue state*. New York, NY: Psychology Press.
- Brown, R., & McNeill, D. (1966). The 'tip of the tongue' phenomenon. *Journal of Verbal Learning and Verbal Behavior*, 5, 325–337. doi:10.1016/S0022-5371(66)80040-3
- Burke, D. M., & Shafto, M. A. (2004). Aging and language production. *Current Directions in Psychological Science*, 13, 21–24. doi:10.1111/j.0963-7214.2004.01301006.x
- Burke, D. M., & Shafto, M. A. (2008). Language and aging. In F. M. Craik & T. A. Salthouse (Eds.), *The handbook of aging and cognition* (3rd ed.; pp. 373–443). New York, NY: Psychology Press.
- Burke, D. M., Locantore, J., Austin, A. A., & Chae, B. (2004). Cherry pit primes Brad Pitt: Homophone priming effects on young and older adults' production of proper names. *Psychological Science*, 15, 164–170. doi:10.1111/j.0956-7976.2004.01503004.x
- Burke, D. M., MacKay, D. G., Worthley, J. S., & Wade, E. (1991). On the tip of the tongue: What causes word finding failures in young and older adults? *Journal of Memory and Language*, 30, 542–579. doi:10.1016/0749-596X(91)90026-G

- Caramazza, A., & Miozzo, M. (1997). The relation between syntactic and phonological knowledge in lexical access: Evidence from the 'tip-of-the-tongue' phenomenon. *Cognition*, 64, 309–343. doi:10.1016/S0010-0277(97)00031-0
- Carstensen, L. L., Isaacowitz, D. M., & Charles, S. T. (1999). Taking time seriously: A theory of socio-emotional selectivity. *American Psychologist*, 54, 165–181. doi:10.1037/0003-066X.54.3.165
- Charles, S. T., Mather, M., & Carstensen, L. L. (2003). Aging and emotional memory: The forgettable nature of negative images for older adults. *Journal of Experimental Psychology: General*, 132, 310–324. doi:10.1037/0096-3445.132.2.310
- Cohen, G. (1994). Age-related problems in the use of proper names in communication. In M. L. Hummert, J. M. Wiemann, & J. N. Nussbaum (Eds.), *Interpersonal communication in older adulthood* (pp. 40–57). Thousand Oaks, CA: Sage. doi:10.4135/9781483326832.n3
- Cohen, G., & Burke, D. M. (1993). *Memory for proper names*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Cohen, G., & Faulkner, D. (1986). Memory for proper names: Age differences in retrieval. *British Journal of Developmental Psychology*, 4, 187–197. doi:10.1111/j.2044-835X.1986.tb01010.x
- Conley, P., Burgess, C., & Hage, D. (1999). Large-scale databases of proper names. *Behavior Research Methods, Instruments, and Computers*, 31, 215–219. doi:10.3758/BF03207713
- Croot, K. (2009). Progressive language impairments: Definitions, diagnoses, and prognoses. *Aphasiology*, 23, 302–326. doi:10.1080/02687030801942981
- Cross, E. S., & Burke, D. M. (2004). Do alternative names block young and older adults' retrieval of proper names? *Brain and Language*, 89, 174–181. doi:10.1016/S0093-934X(03)00363-8
- D'Angelo, M. C., & Humphreys, K. R. (2012). Emotional cues do not increase the likelihood of tip-of-the-tongue states. *Memory and Cognition*, 40, 1331–1338. doi:10.3758/s13421-012-0235-z
- Dahlgren, D. J. (1998). Impact of knowledge and age on tip-of-the-tongue rates. *Experimental Aging Research*, 24, 139–153. doi:10.1080/036107398244283
- Damasio, A. R., & Damasio, H. (1994). Cortical systems for retrieval of concrete knowledge: The convergence zone framework. In C. Koch, & J. L. Davis (Eds.), *Large-scale neuronal theories of the brain* (pp. 62–74). Cambridge, MA: The MIT Press.
- Damasio, H., Grabowski, T. J., Tranel, D., Hichwa, R. D., & Damasio, A. (1996). A neural basis for lexical retrieval. *Nature*, 380, 499–505. doi:10.1038/380499a0
- Delazer, M., Semenza, C., Reiner, M., Hofer, R., & Benke, T. (2003). Anomia for people names in DAT – evidence for semantic and post-semantic impairments. *Neuropsychologia*, 41, 1593–1598. doi:10.1016/S0028-3932(03)00116-7
- Delacourte, A., David, J. P., Sergeant, N., Buée, L., Watzet, A., Vermersch, P., & ... Di Menza, C. (1999). The biochemical pathway of neurofibrillary degeneration in aging and Alzheimer's disease. *Neurology*, 52, 1158–1165. doi:10.1212/WNL.52.6.1158
- Dell, G. S. (1986). A spreading-activation theory of retrieval in sentence production. *Psychological Review*, 93, 283–321. doi:10.1037//0033-295X.93.3.283
- Dell, G. S., & Gordon, J. K. (2003). Neighbors in the lexicon: Friends or foes? In N. O. Schiller & A. S. Meyer (Eds.), *Phonetics and phonology in language comprehension and production: Differences and similarities* (pp. 9–38). Berlin: Mouton de Gruyter.
- Díaz, F., Lindín, M., Galdo-Álvarez, S., & Buján, A. (2014). Neurofunctional correlates of the tip-of-the-tongue state. In B. L. Schwartz & A. S. Brown (Eds.), *Tip-of-the-tongue states and related phenomena* (pp. 198–231). Cambridge: Cambridge University Press.

- Ding, S., Van Hoesen, G. W., Cassell, M. D., & Poremba, A. (2009). Parcellation of human temporal polar cortex: A combined analysis of multiple cytoarchitectonic, chemoarchitectonic, and pathological markers. *The Journal of Comparative Neurology*, 514, 595–623. doi:10.1002/cne.22053
- Dougherty, R. F., Ben-Shachar, M., Deutsch, G. K., Hernandez, A., Fox, G. R., & Wandell, B. A. (2007). Temporal-callosal pathway diffusivity predicts phonological skills in children. *Proceedings of the National Academy of Sciences of the United States of America*, 104, 8556–8561. doi:10.1073/pnas.0608961104
- Estévez-González, A., García-Sánchez, C., Boltes, A., Otermán, P., Pascual-Sedano, B., Gironell, A., & Kulisevsky, J. (2004). Semantic knowledge of famous people in mild cognitive impairment and progression to Alzheimer's disease. *Dementia and Geriatric Cognitive Disorders*, 17, 188–195. doi:10.1159/000076355
- Evrard, M. (2002). Ageing and lexical access to common and proper names in picture naming. *Brain and Language*, 81, 174–179. doi:10.1006/brln.2001.2515
- Farrell, M. T. (2012). *What's in a name? Predictors of proper name retrieval deficits in older age*. Unpublished doctoral dissertation. University of Florida, Gainesville, FL.
- Farrell, M. T., & Abrams, L. (2011). Tip-of-the-tongue states reveal age differences in the syllable frequency effect. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 37, 277–285. doi:10.1037/a0021328
- Fischer, P., Jungwirth, S., Zehetmayer, A., Weissgram, S., Hoenigschnabl, A., Gelpi, E., Krampla, W., & Tragl, K. H. (2007). Conversion from subtypes of mild cognitive impairment to Alzheimer dementia. *Neurology*, 68, 288–291. doi:10.1212/01.wnl.0000252358.03285.9d
- Fogler, K. A., & James, L. E. (2007). Charlie Brown versus Snow White: The effects of descriptiveness on young and older adults' retrieval of proper names. *The Journals of Gerontology: Psychological Sciences and Social Sciences*, 62B, 201–207. doi:10.1093/geronb/62.4.P201
- Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). Mini mental state: A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, 12, 189–198. doi:10.1016/0022-3956(75)90026-6
- Fraas, M. M., Lockwood, J. J., Neils-Strunjas, J. J., Shidler, M. M., Krikorian, R. R., & Weiler, E. E. (2002). 'What's his name?' A comparison of elderly participants' and undergraduate students' misnamings. *Archives of Gerontology and Geriatrics*, 34, 155–165. doi:10.1016/S0167-4943(01)00206-0
- Francis, W. N., & Kucera, H. (1982). *Frequency analysis of English usage: Lexicon and grammar*. Boston, MA: Houghton-Mifflin.
- Gaskell, M. G., & Dumay, N. (2003). Lexical competition and the acquisition of novel words. *Cognition*, 89, 105–132. doi:10.1016/s0010-0277(03)00070-2
- Gollan, T. H., & Brown, A. S. (2006). From tip-of-the-tongue (TOT) data to theoretical implications in two steps: When more TOTs means better retrieval. *Journal of Experimental Psychology: General*, 135, 462–483. doi:10.1037/0096-3445.135.3.462
- Gollan, T. H., Ferreira, V. S., Cera, C., & Flett, S. (2014). Translation-priming effects on tip-of-the-tongue states. *Language, Cognition and Neuroscience*, 29, 274–288. doi:10.1080/01690965.2012.762457
- Gollan, T. H., Montoya, R. I., & Bonanni, M. (2005). Proper names get stuck on bilingual and monolingual speakers' tip of the tongue equally often. *Neuropsychology*, 19, 278–287. doi:10.1037/0894-4105.19.3.278

- Gonzalez Rothi, L. J., Fuller, R., Leon, S. A., Kendall, D. L., Moore, A., Wu, S. S., Crosson, B., Heilman, K. M., & Nadeau, S. E. (2009). Errorless practice as a possible adjuvant to donepezil in Alzheimer's disease. *Journal of the International Neuropsychological Society*, 15, 311–322. doi:10.1017/S15355617709090201
- Gordon, J., & Kurczek, J. (2014). The aging neighborhood: Phonological density in naming. *Language, Cognition, and Neuroscience*, 29, 326–344. doi:10.1080/01690965.2013.837495
- Gorno-Tempini, M., Price, C. J., Josephs, O. O., Vandenberghe, R. R., Cappa, S. F., Kapur, N. N., & Frackowiak, R. J. (1998). The neural systems sustaining face and proper-name processing. *Brain: A Journal of Neurology*, 121, 2103–2118. doi:10.1093/brain/121.11.2103
- Gour, N., Ranjeva, J., Ceccaldi, M., Confort-Gouny, S., Barbeau, E., Soulier, E., & ... Felician, O. (2011). Basal functional connectivity within the anterior temporal network is associated with performance on declarative memory tasks. *Neuroimage*, 58, 687–697. doi:10.1016/j.neuroimage.2011.05.090
- Greene, J. D. & Hodges, J. R. (1996). Identification of famous faces and famous names in early Alzheimer's disease. Relationship to anterograde episodic and general semantic memory. *Brain: A Journal of Neurology*, 119, 111–128. doi:10.1093/brain/119.1.111>
- Gross, J. J., Carstensen, L. L., Pasupathi, M., Tsai, J., Götestam Skorpen, C., & Hsu, A. C. (1997). Emotion and aging: Experience, expression, and control. *Psychology and Aging*, 12, 590–599. doi:10.1037/0882-7974.12.4.590
- Grühn, D., Scheibe, S., & Baltes, P. B. (2007). Reduced negativity effect in older adults' memory for emotional pictures: The heterogeneity-homogeneity list paradigm. *Psychology and Aging*, 22, 644–649. doi:10.1037/0882-7974.22.3.644
- Guedj, E., Barbeau, E. J., Liégeois-Chauvel, C., Confort-Gouny, S., Bartolomei, F., Chauvel, P., & ... Guye, M. (2010). Performance in recognition memory is correlated with entorhinal/perirhinal interictal metabolism in temporal lobe epilepsy. *Epilepsy & Behavior*, 19, 612–617. doi:10.1016/j.yebeh.2010.09.027
- Hanley, J. R. (2011). Why are names of people associated with so many phonological retrieval failures? *Psychonomic Bulletin and Review*, 18, 612–617. doi:10.3758/s13423-011-0082-0
- Hanley, J., & Chapman, E. (2008). Partial knowledge in a tip-of-the-tongue state about two- and three-word proper names. *Psychonomic Bulletin and Review*, 15, 156–160. doi:10.3758/PBR.15.1.156
- Harley, T. A., & Bown, H. E. (1998). What causes a tip-of-the-tongue state? Evidence for lexical neighbourhood effects in speech production. *British Journal of Psychology*, 89, 151–174. doi:10.1111/j.2044-8295.1998.tb02677.x
- Hasher, L., & Zacks, R. T. (1988). Working memory, comprehension, and aging: A review and a new view. In G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 2; pp. 193–225). San Diego, CA: Academic Press. doi:10.1016/S0079-7421(08)60041-9
- Heine, M. K., Ober, B. A., & Shenaut, G. K. (1999). Naturally occurring and experimentally induced tip-of-the-tongue experiences in three adult age groups. *Psychology and Aging*, 14, 445–457. doi:10.1037/0882-7974.14.3.445
- Hodges, J. R., Salmon, D. P., & Butters, N. (1993). Recognition and naming of famous faces in Alzheimer's disease: A cognitive analysis. *Neuropsychologia*, 31, 775–788. doi:10.1016/0028-3932(93)90128-M
- Jack, C. R., Petersen, R. C., Xu, Y. C., Waring, S. C., O'Brien, P. C., Tangalos, E. G., Smith, G. E., Ivnik, R. J., & Kokmen, E. (1997). Medial temporal atrophy on MRI in normal aging and very mild Alzheimer's disease. *Neurology*, 49, 786–794. doi:10.1212/WNL.49.3.786

- Jacobs, H. L., Van Boxtel, M. J., van der Elst, W., Burgmans, S., Smeets, F., Gronenschild, E. M., Verhey, F. R., Uylings, H. B., & Jolles, J. (2011). Increasing the diagnostic accuracy of medial temporal lobe atrophy in Alzheimer's disease. *Journal of Alzheimer's Disease*, 25, 477–490.
- James, L. E. (2004). Meeting Mr. Farmer versus meeting a farmer: Specific effects of aging on learning proper names. *Psychology and Aging*, 19, 515–522. doi:10.1037/0882-7974.19.3.515
- James, L. E. (2006). Specific effects of aging on proper name retrieval: Now you see them, now you don't. *The Journals of Gerontology: Psychological Sciences and Social Sciences*, 61B, 180–183. doi:10.1093/geronb/61.3.P180
- James, L. E. & Burke, D. M. (2000). Phonological priming effects on word retrieval and tip-of-the-tongue experiences in young and older adults. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 26, 1378–1391. doi:10.1037//0278-7393.26.6.1378
- James, L. E., Schmank, C. J., & Castro, N. (2013, August). *Word retrieval is harmed by stressful conditions*. Poster presented at the 121st annual convention of the American Psychological Association, Honolulu, HI. doi:10.1037/e595652013-001
- James, W. (1893). *The principles of psychology* (Vol. 1). New York, NY: Holt.
- Jones, G. V. (1989). Back to Woodworth: Role of interlopers in the tip-of-the-tongue phenomenon. *Memory and Cognition*, 17, 69–76. doi:10.3758/BF03199558
- Jones, G. V., & Langford, S. (1987). Phonological blocking in the tip of the tongue state. *Cognition*, 26, 115–122. doi:10.1016/0010-0277(87)90027-8
- Juncos-Rabadán, O., Facal, D., Lojo-Seoane, C., & Pereiro, A. X. (2013a). Does tip-of-the-tongue for proper names discriminate amnesic mild cognitive impairment? *International Psychogeriatrics*, 25, 627–634. doi:10.1017/S1041610212002207
- Juncos-Rabadán, O., Facal, D., Lojo-Seoane, C., & Pereiro, A. X. (2013b). Tip-of-the-tongue for proper names in non-amnesic mild cognitive impairment. *Journal of Neurolinguistics*, 26, 409–420. doi:10.1016/j.jneuroling.2013.01.001
- Juncos-Rabadán, O., Facal, D., Rodríguez, M., & Pereiro, A. X. (2012). Lexical knowledge and lexical retrieval in ageing: Insights from a tip-of-the-tongue (TOT) study. *Language and Cognitive Processes*, 25, 1301–1334. doi:10.1080/01690961003589484
- Juncos-Rabadán, O., Rodríguez, N., Facal, D., Cuba, J., & Pereiro, A. X. (2011). Tip-of-the-tongue for proper names in mild cognitive impairment. *Semantic or post-semantic impairments?* *Journal of Neurolinguistics*, 24, 636–651. doi:10.1016/j.jneuroling.2011.06.004
- Kahn, I., Andrews-Hanna, J. R., Vincent, J. L., Snyder, A. Z., & Buckner, R. L. (2008). Distinct cortical anatomy linked to subregions of the medial temporal lobe revealed by intrinsic functional connectivity. *Journal of Neurophysiology*, 100, 129–139. doi:10.1152/jn.00077.2008
- Kane, M. J., Hasher, L., Stoltzfus, E. R., Zacks, R. T., & Connelly, S. (1994). Inhibitory attentional mechanisms and aging. *Psychology and Aging*, 9, 103–112. doi:10.1037/0882-7974.9.1.103
- Kessler, E., & Staudinger, U. M. (2009). Affective experience in adulthood and old age: The role of affective arousal and perceived affect regulation. *Psychology and Aging*, 24, 349–362. doi:10.1037/a0015352
- Labouvie-Vief, G., Lumley, M. A., Jain, E., & Heinze, H. (2003). Age and gender differences in cardiac reactivity and subjective emotion responses to emotional autobiographical memories. *Emotion*, 3, 115–126. doi:10.1037/1528-3542.3.2.115
- Lawton, M. P., Kleban, M. H., Dean, J., Rajagopal, D., & Parmelee, P. A. (1992). The factorial generality of brief positive and negative affect measures. *Journal of Gerontology*, 47, P228–P237. doi:10.1093/geronj/47.4.P228

- Laver, G. D., & Burke, D. M. (1993). Why do semantic priming effects increase in old age? A meta-analysis. *Psychology and Aging*, 8, 34–43. doi:10.1037/0882-7974.8.1.34
- Levelt, W. M. (1989). *Speaking: From intention to articulation*. Cambridge, MA: The MIT Press.
- Levenson, R. W., Carstensen, L. L., Friesen, W. V., & Ekman, P. (1991). Emotion, physiology, and expression in old age. *Psychology and Aging*, 6, 28–35. doi:10.1037/0882-7974.6.1.28
- Light, L. L., & Burke, D. M. (1993). *Language, memory, and aging*. Cambridge: Cambridge University Press.
- Longley, M., & Warner, M. (2002). Alzheimer's disease: an introduction to the issues. In M. Warner, S. Furnish, M. Longley, & B. Lawlor (Eds.), *Alzheimer's disease: Policy and practice across Europe* (pp. 1–10). Oxford: Radcliffe Medical Press.
- Lovelace, E. A., & Twohig, P. T. (1990). Healthy older adults' perceptions of their memory functioning and use of mnemonics. *Bulletin of the Psychonomic Society*, 28, 115–118. doi:10.3758/BF03333979
- MacKay, D. G. (1987). *The organization of perception and action: A theory for language and other cognitive skills*. Berlin: Springer. doi:10.1007/978-1-4612-4754-8
- MacKay, D. G., & Burke, D. M. (1990). Cognition and aging: A theory of new learning and the use of old connections. In T. M. Hess (Ed.), *Aging and cognition: Knowledge organization and utilization* (pp. 213–263). Amsterdam: North-Holland. doi:10.1016/S0166-4115(08)60159-4
- Martin, A. (2007). The representation of object concepts in the brain. *Annual Review of Psychology*, 58, 25–45. doi:10.1146/annurev.psych.57.102904.190143
- Mather, M., & Knight, M. (2005). Goal-directed memory: The role of cognitive control in older adults' emotional memory. *Psychology and Aging*, 20, 554–570. doi:10.1037/0882-7974.20.4.554
- Maylor, E. A. (1990a). Age, blocking and the tip of the tongue state. *British Journal of Psychology*, 81, 123–134. doi:10.1111/j.2044-8295.1990.tb02350.x
- Maylor, E. A. (1990b). Recognizing and naming faces: Aging, memory retrieval and the tip of the tongue state. *Journal of Gerontology: Psychological Sciences*, 45, 215–226. doi:10.1093/geronj/45.6.P215
- Maylor, E. A. (1995). Effects of aging on the retrieval of common and proper names. In B. J. Vellas, J. L. Albarede, & P. J. Garry (Eds.), *Mood and cognitive disorders* (pp. 55–73). Berlin: Springer.
- Maylor, E. A. (1997). Proper name retrieval in old age: Converging evidence against disproportionate impairment. *Aging, Neuropsychology, and Cognition*, 4, 211–226. doi:10.1080/13825589708256648
- McClelland, J. L., & Rumelhart, D. E. (1981). An interactive activation model of context effects in letter perception: I. An account of basic findings. *Psychological Review*, 88, 375–407. doi:10.1037/0033-295X.88.5.375
- McDonald, C. R., McEvoy, L. K., Gharapetian, L., Fennema-Notestine, C., Hagler, D. J., Holland, D., & ... Dale, A. M. (2009). Regional rates of neocortical atrophy from normal aging to early Alzheimer disease. *Neurology*, 73, 457–465. doi:10.1212/WNL.0b013e3181b16431
- McWeeny, K. H., Young, A. W., Hay, D. C., & Ellis, A. W. (1987). Putting names to faces. *British Journal of Psychology*, 78, 143–149. doi:10.1111/j.2044-8295.1987.tb02235.x
- Meyer, A. S., & Bock, K. (1992). The tip-of-the-tongue phenomenon: Blocking or partial activation? *Memory and Cognition*, 20, 715–726. doi:10.3758/BF03202721
- Miozzo, M., & Caramazza, A. (1997). Retrieval of lexical-syntactic features in tip-of-the-tongue states. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 23, 1410–1423. doi:10.1037//0278-7393.23.6.1410

- Mortensen, L., Meyer, A. S., & Humphreys, G. W. (2006). Age-related effects on speech production: A review. *Language and Cognitive Processes*, 21, 238–290. doi:10.1080/01690960444000278
- Mund, I., Bell, R., & Buchner, A. (2010). Age differences in reading with distraction: Sensory or inhibitory deficits? *Psychology and Aging*, 25, 886–897. doi:10.1037/a0019508
- Muñoz, M., & Insausti, R. (2005). Cortical efferents of the entorhinal cortex and the adjacent parahippocampal region in the monkey (*Macaca fascicularis*). *European Journal of Neuroscience*, 22, 1368–1388. doi:10.1111/j.1460-9568.2005.04299.x
- NINDS. (2013). Dementia: Hope through research. Retrieved December 9, 2013, from <[http://www.ninds.nih.gov/disorders/dementias/detail\\_dementia.htm](http://www.ninds.nih.gov/disorders/dementias/detail_dementia.htm)>
- Ortega, A., Gómez-Ariza, C. J., Román, P. E., & Bajo, M. T. (2012). Memory inhibition, aging and the executive deficit hypothesis. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 38, 178–186. doi:10.1037/a0024510
- Ossher, L., Flegal, K. E., & Lustig, C. (2013). Everyday memory errors in older adults. *Aging, Neuropsychology, and Cognition*, 20, 220–242. doi:10.1080/13825585.2012.690365
- Paradis, M. (2004). *A neurolinguistic theory of bilingualism*. Amsterdam: John Benjamins. doi:10.1075/sibil.18
- Pearman, A., & Storandt, M. (2004). Predictors of subjective memory in older adults. *Journals of Gerontology: Psychological Sciences & Social Sciences*, 59B, 4–6. doi:10.1093/geronb/59.1.P4
- Perfect, T. J., & Hanley, J. (1992). The tip-of-the-tongue phenomenon: Do experimenter-presented interlopers have any effect? *Cognition*, 45, 55–75. doi:10.1016/0010-0277(92)90023-B
- Petersen, R. C. (Ed.). (2003). *Mild cognitive impairment: Aging to Alzheimer's disease*. Oxford: Oxford University Press
- Proverbio, A., Lilli, S., Semenza, C., & Zani, A. (2001). ERP indexes of functional differences in brain activation during proper and common names retrieval. *Neuropsychologia*, 39, 815–827. doi:10.1016/S0028-3932(01)00003-3
- Pyers, J. E., Gollan, T. H., & Emmorey, K. (2009). Bimodal bilinguals reveal the source of tip-of-the-tongue states. *Cognition*, 112, 323–329. doi:10.1016/j.cognition.2009.04.007
- Quinlan, P. T. (1992). *Oxford Psycholinguistic Database*. Oxford: Oxford University Press.
- Rastle, K. G., & Burke, D. M. (1996). Priming the tip of the tongue: Effects of prior processing on word retrieval in young and older adults. *Journal of Memory and Language*, 35, 585–605. doi:10.1006/jmla.1996.0031
- Reason, J. T., & Lucas, D. (1984). Using cognitive diaries to investigate naturally occurring memory blocks. In J. E. Harris & P. E. Morris (Eds.), *Everyday memory actions and absent-mindedness* (pp. 53–70). London: Academic Press.
- Reilly, J., Martin, N., & Grossman, M. (2005). Verbal learning in semantic dementia: Is repetition priming a useful strategy? *Aphasiology*, 19, 329–339. doi:10.1080/02687030444000787
- Reilly, J. & Peele, J. E. (2008). Effects of semantic impairment on language processing in semantic dementia. *Seminars in Speech and Language*, 29, 32–43. doi:10.1055/s-2008-1061623
- Reilly, J., Troche, J., & Grossman, M. (2011). Language processing in dementia. In A. E. Budson & N. W. Kowall (Eds.), *The handbook of Alzheimer's disease and other dementias* (pp. 336–366). Oxford: Blackwell. doi:10.1002/9781444344110.ch12
- Rendell, P. G., Castel, A. D., & Craik, F. M. (2005). Memory for proper names in old age: A disproportionate impairment? *The Quarterly Journal of Experimental Psychology: Human Experimental Psychology*, 58A, 54–71. doi:10.1080/02724980443000188
- Ridderinkhof, K., Band, G. H., & Logan, G. D. (1999). A study of adaptive behavior: Effects of age and irrelevant information on the ability to inhibit one's actions. *Acta Psychologica*, 101, 315–337. doi:10.1016/S0001-6918(99)00010-4

- Risacher, S. L., Saykin, A. J., West, J. D., Shen, L., Firpi, H. A., & McDonald, B. C. (2009). Base-line MRI predictors of conversion from MCI to probable AD in the ADNI cohort. *Current Alzheimer Research*, 6, 347–361. doi:10.2174/156720509788929273
- Roediger, H. L. (1974). Inhibiting effects of recall. *Memory and Cognition*, 2, 261–269. doi:10.3758/BF03208993
- Ryan, E. B., Kwong See, S., Meneer, W. B., & Trovato, D. (1992). Age-based perceptions of language performance among younger and older adults. *Communication Research (Special Issue on Language and Aging)*, 19, 423–443. doi:10.1177/009365092019004002
- Salthouse, T. A., & Mandell, A. R. (2013). Do age-related increases in tip-of-the-tongue experiences signify episodic memory impairments? *Psychological Science*, 24, 2489–2497. doi:10.1177/0956797613495881
- Scheibe, S., & Carstensen, L. L. (2010). Emotional aging: Recent findings and future trends. *The Journals of Gerontology: Series B: Psychological Sciences and Social Sciences*, 65B, 135–144. doi:10.1093/geronb/gbp132
- Schwartz, B. L. (2002). *Tip-of-the-tongue states: Phenomenology, mechanism, and lexical retrieval*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Schwartz, B. L. (2010). The effects of emotion on tip-of-the-tongue states. *Psychonomic Bulletin and Review*, 17, 82–87. doi:10.3758/PBR.17.1.82
- Semenza, C. (2006). Retrieval pathways for common and proper names. *Cortex*, 42, 884–891. doi:10.1016/S0010-9452(08)70432-5
- Semenza, C. (2009). The neuropsychology of proper names. *Mind and Language*, 24, 347–369. doi:10.1111/j.1468-0017.2009.01366.x
- Semenza, C. (2011). Naming with proper names: The left temporal pole theory. *Behavioural Neurology*, 24, 277–284. doi:10.1155/2011/650103
- Semenza, C., Borgo, F., Mondini, S., Pasini, M., & Sgaramella, M. T. (2000). Proper names in the early stages of Alzheimer's disease. *Brain and Cognition*, 43, 384–387.
- Semenza, C., Mondini, S., Borgo, F., Pasini, M., & Sgaramella, M. T. (2003). Proper names in patients with early Alzheimer's disease. *Neurocase*, 9, 63–69. doi:10.1076/neur.9.1.63.14370
- Shafiq, M. A., Burke, D. M., Stamatakis, E. A., Tam, P. P., & Tyler, L. K. (2007). On the tip-of-the-tongue: Neural correlates of increased word-finding failures in normal aging. *Journal of Cognitive Neuroscience*, 19, 2060–2070. doi:10.1162/jocn.2007.19.12.2060
- Shafiq, M. A., Stamatakis, E. A., Tam, P. P., & Tyler, L. K. (2010). Word retrieval failures in old age: The relationship between structure and function. *Journal of Cognitive Neuroscience*, 22, 1530–1540. doi:10.1162/jocn.2009.21321
- Stamatakis, E. A., Shafiq, M. A., Williams, G., Tam, P., & Tyler, L. K. (2011). White matter changes and word finding failures with increasing age. *PLoS One*, 6, e14496. doi:10.1371/journal.pone.0014496
- Stevenage, S. V., & Lewis, H. G. (2005). By which name should I call thee? The consequences of having multiple names. *The Quarterly Journal of Experimental Psychology: Human Experimental Psychology*, 58A, 1447–1461. doi:10.1080/02724980443000692
- Sunderland, A., Watts, K., Baddeley, A. D., & Harris, J. E. (1986). Subjective memory assessment and test performance in elderly adults. *Journal of Gerontology*, 41, 376–384. doi:10.1093/geronj/41.3.376
- Taylor, J. K., & Burke, D. M. (2002). Asymmetric aging effects on semantic and phonological processes: Naming in the picture-word interference task. *Psychology and Aging*, 17, 662–676. doi:10.1037/0882-7974.17.4.662

- Theocharopoulou, F., Cocks, N., Pring, T., & Dipper, L. T. (2015). TOT phenomena: Gesture production in younger and older adults. *Psychology and Aging*, 30, 245–252. doi:10.1037/a0038913
- Thompson, R., Emmorey, K., & Gollan, T. H. (2005). ‘Tip of the fingers’ experiences by deaf signers: Insights into the organization of a sign-based lexicon. *Psychological Science*, 16, 856–860. doi:10.1111/j.1467-9280.2005.01626.x
- Thompson, S. A., Graham, K. S., Patterson, K., Sahakian, B. J., & Hodges, J. R. (2002). Is knowledge of famous people disproportionately impaired with patients with early and questionable Alzheimer’s disease? *Neuropsychology*, 16, 344–358. doi:10.1037//0894-4105.16.3.344
- Tsai, J. L., Levenson, R. W., & Carstensen, L. L. (2000). Autonomic, subjective, and expressive responses to emotional films in older and younger Chinese Americans and European Americans. *Psychology and Aging*, 15, 684–693. doi:10.1037/0882-7974.15.4.684
- Visser, P. J., Verhey, F. R. J., Hoffman, P. A. M., Sheltens, P., & Jolles, J. (2002). Medial temporal lobe atrophy predicts Alzheimer’s disease in patients with minor cognitive impairment. *Journal of Neurology, Neurosurgery, and Psychiatry*, 72, 491–497.
- Vitevitch, M. S., & Sommers, M. S. (2003). The facilitative influence of phonological similarity and neighborhood frequency in speech production in younger and older adults. *Memory & Cognition*, 31, 491–504. doi:10.3758/BF03196091
- Vorobyov, N. A., & Brown, M. W. (2008). The topography of activity transmission between lateral entorhinal cortex and subfield CA1 of the hippocampus. *European Journal of Neuroscience*, 27, 3257–3272. doi:10.1111/j.1460-9568.2008.06257.x
- Warburton, E., Wise, R. J., Price, C. J., Weiller, C., Hadar, U., Ramsay, S., & Frackowiak, R. S. J. (1996). Noun and verb retrieval by normal subjects: Studies with PET. *Brain: A Journal of Neurology*, 119, 159–179. doi:10.1093/brain/119.1.159
- White, K. K., & Abrams, L. (2002). Does priming specific syllables during tip-of-the-tongue states facilitate word retrieval in older adults? *Psychology and Aging*, 17, 226–235. doi:10.1037//0882-7974.17.2.226
- White, K. K., Abrams, L., & Frame, E. A. (2013). Semantic category moderates phonological priming of proper name retrieval during tip-of-the-tongue states. *Language and Cognitive Processes*, 28, 561–576. doi:10.1080/01690965.2012.658408
- Woodworth, R. S. (1929). *Psychology* (2nd Rev. ed.). Oxford: Holt.
- Yoon, C., May, C. P., & Hasher, L. (2000). Aging, circadian arousal patterns, and cognition. In D. C. Park & N. Schwarz (Eds.), *Cognitive aging: A primer* (pp. 151–171). New York, NY: Psychology Press.
- Young, A. W., Ellis, A. W., & Flude, B. M. (1988). Accessing stored information about familiar people. *Psychological Research*, 50, 111–115. doi:10.1007/BF00309210
- Zacks, R. T., & Hasher, L. (1994). Directed ignoring: Inhibitory regulation of working memory. In D. Dagenbach & T. H. Carr (Eds.), *Inhibitory processes in attention, memory, and language* (pp. 241–264). San Diego, CA: Academic Press.



# Age-related effects on language production

## A combined psycholinguistic and neurolinguistic perspective

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This chapter focuses on the effects of aging on the process of language production from a psycholinguistic, and neurolinguistic perspective. The first section of the chapter provides a detailed description of the language production system by outlining the notions of micro- (i.e., lexical and grammatical) and macrolinguistic (i.e., pragmatic and discourse level) processing and introducing to some of the most influential psycholinguistic models of message production. The second part focuses on psycholinguistic investigations assessing age-related variations in the ability to produce a verbal message. A conclusive section outlines the complex interplay between the neural changes induced by aging and the (re)organization of the language production system.

### Introduction

Language processing is the expression of a complex cognitive function (e.g., Caplan, 1992) that goes through major modifications during the lifespan. It develops quite rapidly and efficiently in early infancy and through childhood (Kuhl et al., 2010), keeps relatively stable after the end of adolescence and during adulthood, and is characterized by a gradual decline in the elderly (Thornton & Light, 2006). These age-related alterations might depend either on the intrinsic deterioration of the linguistic system or on a more general cognitive decline, which affects working and long-term memory, attentional skills, and executive control (Connor, 2001; Wingfield & Tun, 2001). However, the overall effects of aging on language processing are likely the result of a complex interplay between these two extremes. Difficulties in working memory, attention, and executive functions might hamper the ability to organize the information at the text level in older adults (e.g., Collette et al., 2007). During the production or the comprehension

of a discourse or conversation a reduction in the efficiency of working memory might affect the storage and manipulation of information, syntactic processing, and the stages of message planning and monitoring (e.g., Wingfield & Stine-Morrow, 2000). In a similar way, attentive deficits and impairments in executive functions might prevent older adults from inhibiting the selection of inappropriate information (leading, for example, to the production of verbose speech samples and off-topic utterances; e.g., Zacks & Hasher, 1997; Mozeiko et al., 2011).

In this chapter we will review the complex relation between aging and language production from a combined linguistic, psycholinguistic and neurolinguistic perspective. The chapter is divided in three major sections. The first section will outline the language production system. The second section will focus on psycholinguistic investigations assessing age-related variations in linguistic production. The final section will discuss the age-related neural changes that affect the ability to produce verbal messages across the adult lifespan.

## **Psycholinguistic accounts of language production**

Language production relies on the interaction between several processing levels. These can be analyzed along two dimensions (Glosser & Deser, 1990; Caplan, 1992; Marini et al., 2011a). The microlinguistic dimension of analysis focuses on intra-sentential (i.e., within-utterance) organization of discourse production by assessing those phonetic, phonological and morphological skills that are required to produce well-formed words (lexical processing) and those morphosyntactic and syntactic abilities that eventually lead to the generation of well-formed sentences (syntactic processing). The macrolinguistic dimension analyses inter-sentential (i.e., between-utterances) processing by assessing the speaker's ability to produce contextually appropriate words and utterances (pragmatic processing), connect different utterances by means of cohesive and coherent ties in order to formulate the main theme of a narrative discourse or the gist of a conversation, and integrate its linguistic and conceptual features while taking into account the conversational expectations of the interlocutors (Grice, 1975; Kintsch & van Dijk, 1978; Kintsch, 1994; Garrod & Pickering, 2004).

During every-day communicative interactions, the different levels of linguistic processing are constantly interacting with each other. A number of psycholinguistic models have been proposed to describe such interactions. For example, according to Fromkin (1971) and Garrett (1975), speech production is a multistage process, which requires the speaker to first generate the meaning of the message to be conveyed and then formulate its syntactic organization, determine its prosodic contour, select the target words, and identify their phonological characteristics.

Other models, such as the connectionist model proposed by Dell (1986), hypothesize the existence of different nodes (phonological, semantic, etc.) that interact with each other and process the information in parallel. According to one of the most influential psycholinguist models (Levelt, 1989; Levelt, Roelofs, & Meyer, 1999), the process of language production undergoes at least three major stages: a pre-linguistic conceptual phase; a phase of linguistic formulation; a phase of linguistic expression.

In the **pre-linguistic conceptual phase** the speaker needs to generate the motivation to speak and a mental or situation model of the intended message, a multi-dimensional representation which contains information about space, time, causality, intentionality, and currently relevant individuals (e.g., Johnson-Laird, 1980, 1983; Zwaan & Radvansky, 1998). S(he) generates such mental models by retrieving the appropriate conceptual frame structure from long-term episodic memory (e.g., by selecting the appropriate discourse genre) and by embedding it with the available conceptual information (e.g., participants, setting, etc.). Furthermore, the speaker must integrate what (s)he intends to say with what has previously been said (linguistic context) and the particular situation, place and time in which the communicative exchange takes place (extra-linguistic context, Levinson, 1983). It has been hypothesized that at this stage a pivotal role is played by a supervisory attentional system (SAS: Norman & Shallice, 1986; Green, 1998) that monitors the selection of the appropriate communicative intention, if the amount of information is adequate and if it is relevant to the linguistic context (Grice, 1975; Sperber & Wilson, 1986).

In order to be eventually transferred to an interlocutor, this preverbal message must be converted into a speech plan. This process takes place in the second stage of message production: the **phase of linguistic formulation**. Here, the system needs to match the intended meaning formulated in the pre-linguistic phase with the corresponding lexical items stored in the mental lexicon. This operation is performed through a phase of lexical selection and one of lexical access. The process of lexical selection allows speakers to select the lexical items that correspond to the intended meanings (Levelt et al., 1999). This selection is likely achieved through an activation/inhibition mechanism. Each word is supposed to have its own specific activation thresholds as a function of the frequency of its use and time elapsed since its last activation: The lower the threshold level, the easier the access; the higher the threshold level, the more difficult the access. The activation of the target word is achieved through the simultaneous inhibition of semantically related competitors (Green, 1986, 1998). This inhibition may be obtained by raising the competitors' activation thresholds. For example, if the speaker's intention is to speak out the word "table", the activated concept corresponding to the idea of TABLE enters the lexicon where a selection mechanism

is needed in order to select the target word (“table”) among all other semantically related lexical items (“chair”, “sofa”, etc.). Consequently, the activation threshold of the competitors *is raised* while the target word gets selected. At the end of the process of lexical selection, the target word has been activated and the system gains access to its morphosyntactic and morphological features (lemma level of word representation) and then to its syllabic and phonological form. In the case of single word production this phonological information is then transmitted to the systems responsible for motor planning and execution, where articulatory configurations corresponding to the phonemes to be uttered are programmed and then implemented. In the case of sentence production, such as in connected speech, the process of lexical selection and the access to a word’s lemma form the “functional level” of sentence processing, where the morphosyntactic information required by the selected word (i.e., its argumental structure) guides the process of sentence generation by means of thematic roles’ assignment and phrase generation. At the second level of sentence processing, the “positional level”, i.e. the information contained in the lemmas of the selected words, is used to generate the grammatical relations among the phrases and to build up well-formed syntactic representations (Chomsky, 1995; Garrett, 1980). It is now possible to have access to the syllabic and phonological representation(s) of the selected word(s) and this information is eventually sent to the output system where articulatory configurations corresponding to the phonemes to be uttered are programmed and then implemented (**phase of linguistic expression**). At the end of this stage verbalization actually takes place. During a conversation, these stages must be continuously processed in order to guarantee an efficient interaction between the interlocutors. Indeed, conversation is a joint activity (Clark, 1996) that requires a largely unconscious interactive alignment (Garrod & Pickering, 2004; Pickering & Garrod, 2004) between the concepts selected and organized in the mind of the speaker and those that the receiver needs to deduce from the message.

### Cognitive functions affecting the process of message production

Attention is assumed to play an important role in the pre-linguistic conceptual phase. Obviously, the role played by attention cannot be limited to just this stage of linguistic production but extends also to the phases of linguistic formulation and expression.

Furthermore, the process of message production is also intimately linked to other cognitive skills such as executive functions and memory (e.g., Mozeiko

et al., 2011; Miyake et al., 2000; Tucker & Hanlon, 1998; Ylvisaker et al., 2001). Indeed, according to Mozeiko et al. (2011), three major types of executive functions seem to play an important role in efficient discourse processing: *shifting*, involved in the generation of complete episodes within a narrative discourse and in the selection of informative words; *updating*, required to recall former episodes or episodic contents for an accurate organization of the story; *inhibition*, important for monitoring the production of extraneous comments and derailments while generating a story.

As for memory, according to the Declarative/Procedural model (Ullman, 2004), language learning and representation are subserved by two anatomically and functionally distinct systems of long-term memory (declarative and procedural, respectively). Procedural memory subserves implicit linguistic competence. It is a form of implicit memory implemented in frontal/basal ganglia circuits as well as in portions of the parietal cortex, superior temporal cortex, and the cerebellum (Ullman, 2001). During first language acquisition, procedural memory is involved in the process of learning and executing sensory-motor and cognitive skills such as those involved in the articulation of the sounds of a language and in syntax. Declarative (or explicit) memory is implemented in bilateral medial and temporo-parietal structures, including the hippocampal region and the parahippocampal cortex (Ullman, 2001). It is implicated in conscious learning of facts and events and consists of at least two subtypes: semantic and episodic memory. *Semantic memory* is the system storing one's encyclopedic knowledge of the world (e.g., knowledge about the meaning of words, as well as knowledge about historical events, geographical notions, and social facts). *Episodic memory* refers to one's past experiences that can be consciously recalled. It is assumed that grammar (i.e., implicit syntactic and morphosyntactic competence) is acquired incidentally through procedural memory, whereas lexical-semantic explicit knowledge is consciously learned and stored in declarative memory. For example, procedural memory is involved in the acquisition and use of implicit procedures of syntactic parsing (Frazier & Fodor, 1978). Moreover, once the access to a lexical item is granted, implicit memory procedures automatically generate the argument structure of that particular word and assign the thematic roles to the required arguments (morphosyntactic processing). As to phonetics, the articulatory sequences necessary to produce the target phones of a language become automatized and are transferred to procedural memory, so that the speaker does not need to think about all the articulatory movements required by the process of speaking.

## **Psycholinguistic investigations assessing age-related variations in linguistic processing**

A core feature of healthy aging is a general slowing in a variety of cognitive functions (e.g., Salthouse, 1996). The studies that investigated age-related linguistic differences have provided controversial results. According to Burke, Mackay, and James (2000), aging affects comprehension and production asymmetrically. The quality of discourse production declines with age. On the contrary, text comprehension is basically spared by aging. Indeed, the poorer performance in discourse comprehension shown by older adults is often linked to hearing disturbances (Schneider, Daneman, & Murphy, 2000; Schneider, Daneman, & Pichora-Fuller, 2002) rather than more central processes involved in the ability to derive an appropriate mental model during comprehension (Radvansky, Copeland, & Zwaan, 2003; Radvansky, Greard, Zacks, & Hasher, 1990). In this section of the chapter we will analyze the impact of aging at both micro- and macrolinguistic levels of language production. Most of the studies that focused on age-related effects on language processing have analyzed specific aspects of linguistic production. This led to several reports about age effects on selective linguistic skills without providing a comprehensive account of the patterns of linguistic change across the lifespan. This is a particularly delicate issue, as some studies have reported some null effect of age (e.g., in phonological processing), some effects with a sharp drop in performance only over 70 years of age (e.g., in the production of semantic substitutions and morpho-syntactic weakening), and some others effects suggesting a gradual decrease in performance across age-groups (e.g., Marini et al., 2005).

### **Age-related effects on microlinguistic aspects of message production**

Studies reporting age-related effects on selective aspects of microlinguistic processing have often yielded controversial results. For example, some of these reported declines in older adults in lexical retrieval (Au et al., 1995; Bowles & Poon, 1985; Nicholas, Obler, Albert, & Goodglass, 1985; see also Chapter 8 for language changes in oldest-old) and in syntactic complexity (Shadden, 1997), whereas others failed to detect any age-related difference between younger and older adults in these abilities (e.g., Lyketsos, Chen, & Anthony, 1999). We will now discuss more deeply the effects of aging on lexical and grammatical processing, respectively.

## Age-related effects on lexical processing

A positive aspect associated with aging is that the mental lexicon keeps on growing and that there is little loss of word knowledge with the exception of the oldest individuals (Verhaegen, 2003). Older adults have larger vocabularies than younger ones (Rastle & Burke, 1996; Schroeder & Salthouse, 2004; Thornton & Light, 2006) even if this lexical knowledge begins to slowly decline in people in their 80s and 90s (Lindenberger & Baltes, 1997).

Older people often experience word-finding difficulties (Albert et al., 2009; Connor et al., 2004; Griffin & Spieler, 2006). Such problems have been detected in studies using different paradigms. For example, one line of evidence of this reduction in the ability to retrieve words from the mental lexicon derives from the observation that older persons achieve lower scores on tests assessing rapid naming skills (e.g., the Boston Naming Test [Kaplan et al., 1983] or verbal fluency tasks) (Goral, Spiro, Albert, Obler, & Connor, 2007; MacKay, Connor, Albert, & Obler, 2002). However, not all studies that employed naming tasks to assess age-related changes in lexical retrieval have found deteriorated naming skills in older adults (for a critical review see Goulet, Ska, & Kahn, 1994). Several factors might have affected the results of these experiments, including the selection of highly familiar items, the inclusion of few naming trials and of heterogeneous age-groups with younger participants ranging from 18 to 65 and older ones from 59 to 85 years old (see also Verhaegen & Poncelet, 2012). Those studies that assessed naming performance in healthy adult participants of different ages showed a mild decrease in participants in their 50s (e.g., Connor et al., 2004) and a more important decline over the age of 70 (Feyereisen, 1997). Verhaegen and Poncelet (2012) showed that, with respect to younger participants, those in their 50s had increased naming latencies, whereas adults in their 60s and 70s had decreased accuracy and increased latency scores. Interestingly, these findings are further corroborated by other studies that showed reduced speech rates in the elderly (e.g., Duchin & Mysak, 1987; Fozo & Watson, 1998).

A second source of information about age-related weakening in lexical retrieval comes from those studies that analyzed Tip-of-the-Tongue states (TOT; Brown & McNeill, 1966; for comprehensive review of TOT see also Chapter 2). These are characterized by a selective inability to produce a word stored in the mental lexicon also when speakers have access to word-related grammatical information (e.g., Badecker, Miozzo, & Zanuttini, 1995; Vigliocco, Garrett, & Antonini, 1997) and even to some residual phonological and syllabic information (Brown, 1991). Therefore, from a cognitive point of view, TOT states seem to reflect a temporary disturbance in the process of phonological access rather than a disturbance in the

process of lexical selection (James & Burke, 2000). TOT frequency, especially for proper names, increases with age (e.g., James & Burke, 2000; James, 2004).

Overall, then, studies assessing naming skills and TOT states in healthy aging show that the ability to retrieve words from memory weakens after the age of 50 but significantly deteriorates in people in their 70s. Furthermore, they suggest that this pattern does not reflect a deterioration in lexical knowledge. It does not reflect a deterioration of lexical selection skills either. Rather, it seems plausible that older people experience a problem in the retrieval of specific bits of lexical information: not grammatical but phonological in nature. A few major hypotheses have been formulated to explain these findings. According to one of these hypotheses, some language processes become less efficient with aging because of a more general cognitive slowing (Salthouse, 1996) that might affect the cognitive processes involved in lexical retrieval. Alternatively, these problems might be the consequence of reduced working memory skills (Carpenter et al., 1994) or in the ability to inhibit the activation of irrelevant lexical nodes (Zacks & Hasher, 1997). A final possibility is that age-related changes in lexical retrieval stems from weakened connections among lexical-semantic and phonological representations in the mental lexicon that might eventually lead to more lexical retrieval difficulties in the elderly (Transmission Deficit Hypothesis – e.g., Burke & Shafto, 2004).

A final consideration relates to the need for ecological tests to assess lexical skills. Schmitter-Edgecombe et al. (2000) compared word-finding skills in three groups of adults. They administered the Boston Naming Test and a spontaneous discourse production test. Interestingly, the group of older adults (aged 73–95 years old) produced more errors than younger participants in the latter task. In the picture naming task, however, they were surprisingly more accurate than younger controls. These findings have important theoretical and clinical implications, indicating that a test of spontaneous discourse production may prove more informative about the actual linguistic difficulties experienced by a given individual. Therefore, “clinicians should consider stimuli type when measuring discourse ability” (Capilouto et al., 2005, p. 431).

### **Age-related effects on grammatical processing**

Investigations focusing on the syntactic level of message production have shown that grammatical skills also decline gradually with age (Kemper et al., 2001). For example, when compared to younger subjects, older adults tend to produce fewer complex sentences (e.g., Kemper & Anagnopoulos, 1989; Shadden, 1997), have more difficulties in the retrieval of pronouns and closed-class words (Heller & Dobbs, 1993) and in the generation of subject-verb agreement links between

words (Thornton et al., 2004). Interestingly, the grammatical difficulties observed in persons in their 70s apparently correlate with scores obtained on tasks assessing the functionality of working memory such as the digit span test (Kemper & Sumner, 2001). This suggests that the age-related weakening of their grammatical skills might be (partly) related to a more general cognitive decline affecting short-term and working memory. Kemper et al. (2004) compared the ability to generate complex sentences in a group of thirty-four young adults aged 18 to 28 years and one of thirty-nine older ones aged 70 to 80 years. The participants were instructed to produce, as fast as they could, sentences using previously memorized sentence fragments formed by three words. Overall, older adults produced less complex sentences than young adults. Interestingly, the performance of younger adults was affected by the complexity of the syntactic manipulation whereas that of the older ones was not. According to the authors, processing limitations including reduced working memory might impose a “ceiling” on older adults’ performance, not allowing them to retain the information necessary for further processing.

The possibility of an age-induced morpho-syntactic and grammatical weakening is further supported by the results from studies using more ecological tasks. For example, in a study where the picture descriptions of healthy adults of different age-ranges were analyzed, Marini et al. (2005) reported weakened morphological processing (in terms of the production of paragrammatic errors) and lower levels of syntactic complexity in a group of participants in their 70s. Interestingly, however, Glosser and Deser (1992) did not find any significant age-related difference between middle-aged and older individuals on microlinguistic measures, neither for syntactic complexity, nor for lexical production errors. This discrepancy might depend on the use of different tasks to elicit the linguistic production. Glosser and Deser’s analysis was based on informal interviews, whereas the method of speech elicitation in Marini et al. (2005) was a picture description task. In informal interviews it is more difficult to evaluate the appropriateness of word choice and the completeness of syntactic structures than in picture description tasks. Another possible reason for these differences in results could be that, in contrast to English, Italian is a morphologically rich language with requirements for gender and number agreement on nouns, adjectives, verbs and even prepositions within and across utterances. As morphological agreement becomes harder to maintain, speakers would start to make more errors and might also tend to produce less complex sentences in order to avoid ungrammaticality. Overall, these findings highlight the importance of conducting studies in languages with different typological structures but also reaffirm the need for using highly ecological and reliable methods for eliciting speech samples to assess specific age-related changes in language production.

## Age-related effects on macrolinguistic aspects of message production

Age-related changes have been reported also for macrolinguistic aspects of linguistic processing. As noted earlier, discourse production is a complex procedure, which relies on several cognitive functions (e.g., working and long-term memory, attention, executive functions). Interestingly, the investigations focusing on age-related differences in these high level skills have provided a complex picture. Older adults have been shown to possess higher structural abilities in the construction of a text. For example, their written diaries and personal narratives may include more embedded episodes than those produced by younger adults (e.g., Kemper, 1990; Pratt & Robins, 1991). However, their discourse is characterized by augmented verbosity (Gold & Arbuckle, 1995), decreased levels of cohesiveness and of both local and global coherence (e.g., Marini et al., 2005). Cohesiveness reflects the structural connectivity across contiguous utterances, whereas local coherence is related to their conceptual connectivity. Cohesive errors might include the misuse of cohesive ties such as anaphoric pronouns, errors in number and gender agreement between pronouns or noun phrases across utterances, misuse of either cohesive function words or semantically related content words, and abrupt interruptions of utterances. Similarly, problems with local coherence might induce speakers to produce words with ambiguous referents or interrupt the flow of concepts in a discourse or conversation by leaving some topics incomplete while introducing new pieces of information. This ability has been found weakened in the elderly (Juncos-Rabadán et al. 2005; Ulatowska et al. 1986). More specifically, Marini et al. (2005) reported a sharp decrease in the ability to coherently link individual utterances in individuals older than 75. These individuals produced a significantly higher rate of local coherence errors than the younger adults in terms of more missing or ambiguous referents and topic shifts which undermined the levels of local coherence of their picture descriptions. The absence of significant differences between the oldest group's performance and that of the middle-aged and the young elderly suggests that the production of local coherence errors is a gradual side-effect of aging, which is likely to start already in the middle-aged group.

Aging weakens global coherence as well. Global coherence refers to the ability to semantically relate remote utterances in the framework of a given discourse or written text. Consequently, errors of global coherence might include the production of tangential utterances, utterances conceptually incongruent with the story, or simply fillers. Indeed, when older adults are involved in spontaneous conversation, they produce more off-topic speech than younger adults (Arbuckle & Gold, 1993; James et al., 1998; Trunk & Abrams, 2009; Wills et al., 2012): they may initially provide relevant pieces of information but then introduce additional

information that can be loosely related or even entirely unrelated to the main topic of the conversation and/or discourse. For all these reasons, the speech output of older people is often perceived as vague and incoherent.

As already seen for lexical and grammatical processing, the narrative difficulties observed in the elderly might not depend on a linguistic disturbance *per se*. Indeed, according to the *inhibition deficit hypothesis* (Hasher & Zacks, 1988) older adults might be less able to suppress irrelevant pieces of information than younger ones because of a decline in their ability to monitor the process of message production. This might eventually trigger the introduction of extraneous comments and derailments while generating a story (Thornton et al., 2004). Important components of the ability to inhibit irrelevant information are selective and shifting attention (Drag & Bieliauskas, 2010; Wager, Jonides, & Reading, 2004). For this reason, some studies have investigated the potential interconnections between declines in attention and augmented off-topic verbosity in narrative production tasks (Arbuckle & Gold, 1993; James et al., 1998; Trunk & Abrams, 2009; Wills et al., 2012). Arbuckle and Gold (1993) analyzed attentional skills and off-topic verbosity in the biographical recounts produced by a large sample of 196 adults aged 61 to 90. Attentional measures included a test tapping shifting attention (Trail-Making Test) and one measuring inhibition and perseveration (Wisconsin Card-Sorting Test, WCST). In this study, age had a significant impact on both attention skills and production of off-topic speech. Furthermore, the performance on the WCST predicted participants' off-topic verbosity; this finding clearly supports the inhibition deficit hypothesis. In a second study, James et al. (1998) asked 20 younger and 20 older adults to recount personal events and perform a picture description task. The older group produced more off-topic speech only when producing personal narratives but not while performing the picture description task. As autobiographical recounts might trigger the activation of several irrelevant topics that a well-functioning cognitive system should inhibit in the phase of message planning, the authors considered this result as an indirect support to the inhibition deficit hypothesis.

In a pilot study, Wills et al. (2012) administered to five small groups of healthy adults ranging from 40 to 80 years of age (six participants per cohort) a series of tasks assessing attention (the Comprehensive Trail-Making Test and the STROOP Color and Word Test) and a series of discourse production tasks eliciting recounts of personal events. In this study, the age groups differed in the measures of attention. On the other side, no age-related differences were found in the production of off-topic speech and the measures of attention and off-topic verbosity were not correlated. However, this is just a pilot study and the results are based on cohorts of participants that are too small to draw firm conclusions. Therefore, it seems plausible that the increased macrolinguistic difficulties are at least partially related

to a more general cognitive decline induced by aging. Healthy aging does not affect all individuals in the same way. With age, the inter-individual variability increases significantly. This means that, in theory, a specific ability might be preserved in one person but weakened in another. For example, Obler et al. (1994) reported a marked increase in variability with age in narrative length. Similarly, in Marini et al. (2005) the group of participants in their late70s–mid80s showed a relevant intra-group variation in almost all measures assessing microlinguistic, macrolinguistic, and informative aspects of discourse production. However, this variability was significantly lower in the levels of syntactic complexity, in the degree of global coherence, and in a measure of thematic informativeness. This suggests that the ability to build syntactically well-formed sentences, organize a narrative discourse following rules of global coherence, and extract the expected concepts from the story were consistently affected in the group of individuals in their mid70s–early80s.

### **Effects of aging on the neural networks subserving the process of linguistic production**

As we have seen in the former paragraphs, language is a complex cognitive function prone to changes along the lifespan. Importantly, such changes are selective and subject to high inter-individual variability. Some abilities (e.g., articulatory skills) appear to be less affected by the process of aging than others (e.g., lexical selection and/or access) but not in all individuals or at the same rate. A good way to enhance our understanding of the mechanisms involved in linguistic deterioration during aging stems from the analysis the neural correlates of message production in the elderly.

Initially, the way to study the cerebral organization of language had been the observation of patients with specific lesions resulting in selective linguistic disturbances. This neuropsychological approach allowed scholars to identify in the left hemisphere a number of cortical areas potentially involved in lexical processing (e.g., Geschwind, 1970). Over the past 20 years, the development and massive use of functional neuroimaging techniques (e.g., Positron- Emission Tomography, PET; Functional Magnetic Resonance Imaging, fMRI; Near-Infrared Spectroscopy, NIRS; Diffusion Tensor Imaging tractography, DTI) has dramatically advanced our knowledge about the neural underpinnings of language processing in healthy individuals (e.g., Catani et al., 2012; Marini & Urgesi, 2012; Vigneau et al., 2006). Overall, these studies have suggested the possibility to pinpoint the neural networks recruited during the different phases of message production outlined in paragraph 2 (e.g., Indefrey & Levelt, 2000; 2004; Indefrey, 2011).

During the **pre-linguistic conceptual phase**, where the speaker needs to conceptualize the preverbal message and eventually extract the corresponding lexical concepts, vast areas in bilateral frontal lobes, deeply interconnected via inter- and intra-hemispheric pathways, are recruited. These include neural networks linked to the generation of the motivation to speak (i.e., anterior cingulate cortex – Brodmann's area [BA] 24; orbitofrontal cortex – BAs 47 and 11; supplementary motor area – BA 6), and those in areas linked to executive abilities such as those involved in planning, monitoring and inhibiting (i.e., the dorso-lateral prefrontal cortex – BAs 8, 9, 45, 46; Fletcher et al., 1995). This suggests that the frontal lobes, particularly prone to age-induced functional and structural modifications (Cabeza et al., 2002; Grady et al. 2003), play a key role in this first stage of message production. Indeed, altered patterns of activation and reduced inter-hemispheric asymmetry for older people during the execution of cognitive tasks have been widely documented for both prefrontal and anterior cingulate cortex (Grady & Craik, 2000; Madden et al., 1999; Park et al., 2003; Sharp et al., 2006). Two studies, in particular, showed in older participants reduced patterns of activation in the left prefrontal cortex on a task of episodic memory encoding (Cabeza et al., 1997) and in the left inferior frontal gyrus on a task assessing the self-initiated encoding of words (Logan et al., 2002). As these two abilities are obviously linked to the phases of message generation and lexical selection, the mentioned studies provide indirect support to the possibility that the reduced functionality of the frontal lobes of elder individuals might exert a significant impact on their message production skills. Furthermore, as both anterior cingulate and dorsolateral prefrontal cortices play a role in cognitive control, these alterations are likely linked to the difficulty that most elder people experience when they need to plan, monitor, inhibit a new action, schema or narrative discourse. From a linguistic point of view, this explains both the reduced levels of lexical appropriateness and the production of global coherence errors observed in healthy older adults (Marini et al., 2005) and persons with frontal lesions (e.g., persons with Traumatic Brain Injuries, Marini et al., 2011b).

The **phases of lexical selection and access** require the coordination of an articulated cohort of cortical and subcortical areas. The selection of the appropriate word is linked to the activation of portions of the left temporal lobe (temporal pole – BA38; posterior aspect of the inferior temporal lobe – BA37; mid-portions of the inferior and middle temporal gyri – BAs 21 and 20), the posterior aspect of left pars opercularis (BA44), the precentral sulcus (BA 6) and the dentate nucleus of the right cerebellar hemisphere (Damasio et al., 1996; Fiez et al., 1996; Marini & Urgesi, 2012; Price & Friston, 1997). Indeed, the right cerebellar hemisphere is connected to the frontal lobes through a cortical-ponto-cerebellar and cerebellar-thalamo-cortical loop (Schmahmann & Pandya, 1997) also dedicated to lexical

production (Sach et al., 2004). As such, it may play a role in word search, whereas the prefrontal cortex seems to underlie the selection of words from among competing alternatives (Marvel et al., 2004). Similarly, the **phase of lexical access to the word's morphosyntactic information** involves the posterior aspect of left pars opercularis (BA44), whereas the one of **phonological encoding** is implemented in areas in the left auditory cortex and *planum temporale* together with the posterior aspects of the left superior temporal gyrus (Hickok et al., 2003; Levelt et al., 1998). As we have seen, the increase of TOT phenomena with aging and other lexical difficulties suggest that the phases of lexical selection and access undergo significant changes in many older individuals. Indeed, word retrieval difficulties in older people have been found associated with atrophy in neural networks implicated in lexical selection and access, including white matter integrity (Stamatakis et al., 2011). In an fMRI investigation, Peelle et al. (2013) asked a group of younger and one of older healthy adults to judge whether two object names matched on a particular semantic feature. The results showed that both groups had similar performance levels but older adults were more variable. Namely, the authors could distinguish between a high- and a low-performing subgroup, with the former having the same performance as the younger group but increased overall activity in bilateral premotor cortex and left lateral occipital cortex. This suggests that with aging, the brain of elder people may cope with the atrophic processes by reshaping some of the neural connections previously employed in specific tasks. For example, the left lateralized activity observed in prefrontal areas while performing tasks of word-retrieval has been found to occur with additional activations in the right prefrontal cortex in older individuals (Meinzer et al., 2009; Persson et al., 2004; Wierenga et al., 2008). After the phases of lexical selection and access to morphosyntactic and phonological information, the speaker gains access to the **phases of syllabification and phonetic encoding**. Several studies show that these processes recruit a cohort of cortical and subcortical areas (left inferior frontal gyrus – BA44; ventral aspect of left precentral gyrus – BA6; mid-portion of bilateral superior temporal gyri; posterior aspect of left fusiform gyrus – BAs 21 and 37; left thalamus; mid-portion of right cerebellar hemisphere) (Hagoort et al., 1999; Indefrey & Levelt, 2004). Finally, the **phase of articulation** is implemented in areas involved in articulatory planning (supplementary motor area) and control (primary motor cortex – BA4; cerebellum; left thalamus; basal ganglia) (Price et al., 1999; Rieker et al., 2005). Overall, then, the phases of phonological and phonetic encoding, and that of articulation recruit different cortical and subcortical networks. Importantly, aging apparently reshapes these neural networks as older individuals show additional activations in specific areas (e.g., ventral premotor cortex, supplementary motor area, prefrontal cortex) but reduced activity in other regions (e.g., posterior superior temporal gyrus) (e.g., Soros et al., 2011).

Tremblay et al. (2013) analyzed the cortical activations in younger and older adults during audio-visual speech perception and production tasks. As for production, their study showed that the wide bilateral network of motor and premotor areas that are recruited for the phase of speech planning and production was not affected by age. However, other areas implicated in the same process such as the Supplementary Motor Area showed reduced activation in the elderly.

The before-mentioned aging-induced structural and functional changes in both grey and white matter (Davis et al., 2009; Good et al., 2001; Raz et al., 2005; Resnick et al., 2003; Tyler et al., 2010) are likely the result of brain plasticity in response to neural loss. However, as we have seen, the impact of healthy aging on cognitive functioning is characterized by high inter- and intra-individual variability. An intriguing issue regards the reason why some older individuals still have good performance on tasks tapping language skills in spite of the general age-related atrophy that affects both grey and white matter. As a result of these neural alterations, several investigations have noticed different patterns of activation between younger and older adults, with older adults showing more widespread and less focused activation while processing specific tasks (e.g., Ghisletta & Lindenberger, 2003; Park et al., 2004). It seems, then, that aging, at least in part, modifies the array of neural structures employed for message production in healthy adults. Overall, these observations support the possibility that as neural structures decline with age other areas are recruited to preserve the function (Meunier et al., 2014). One possibility is that the brain implements compensatory mechanisms to establish new connections between preexisting neural networks and new ones during aging. For example, the **HAROLD model** (Hemispheric Asymmetry Reduction in Older Adults) formulated by Cabeza et al. (2002) hypothesizes that aging would reduce the functional hemispheric asymmetry and therefore compensatory neural networks in both hemispheres would process most cognitive functions. For example, this compensatory mechanism has been observed in older adults in tasks tapping their skills of verbal working memory and inhibitory control, cognitive skills that significantly affect the phases of message planning and monitoring (Cabeza et al., 2002; Ska et al., 2009). When it comes to language, as previously noted, some steps of the process of message production are assumed to be mostly left lateralized in healthy adults (at least in the vast majority of left-handers; Risse et al., 1997). However, when compared to younger individuals, increased bilateral activity has been observed in older persons with good performance on lexical (naming and verbal generation) and syntactic tasks (Persson et al., 2004; Obler et al., 2010; Tyler et al., 2010; Wierenga et al., 2008). A second type of compensatory mechanism, this time not inter- but intra-hemispheric, that has been hypothesized is the **Posterior-Anterior Shift in Aging (PASA) model** (Davis et al., 2008). In the fMRI study by Davis et al. (2008)

a group of younger and one of older adults were scanned during episodic retrieval and visual perceptual tasks. The authors reported age-related changes in brain activity common to both tasks that were not linked to task difficulty.

Furthermore, the age-related increases in frontal activity were positively correlated with performance and negatively correlated with the age-related occipital decreases. The authors hypothesized a reorganization of activation from the occipito-temporal to the frontal cortex as it is also suggested by the results from a preceding study by Grossman et al. (2002) who showed increased prefrontal activity in a group of older individuals with good performance on a language comprehension task. Finally, a third hypothesis (labelled **Cognitive Reserve**; Stern, 2009) focuses on the inter-individual differences found on cognitive tasks in the elderly and suggests that these might depend on differences in cognitive processing and neural implementation that would allow some people to cope better than others with aging and/or brain lesions.

## Conclusions and future directions

This chapter has shown the complex features of linguistic production in aging. It presents results from both psycholinguistic and neurolinguistic perspectives. Indeed, different hypotheses tried to explain changes in the linguistic processing of older adults. From a psycholinguistic point of view, several investigations focused on the hypothesis of a general slowing in a variety of cognitive functions in healthy aging. For instance, studies focusing on lexical retrieval skills revealed that there is a positive aspect associated with aging: the mental lexicon keeps on growing with age. However, older people often go through word finding difficulties. This may be associated with (1) a general cognitive slowing, (2) reduced working memory skills, or (3) a problem in the retrieval of specific lexical information. Also, according to another hypothesis, connections among lexical-semantic and phonological representations in the mental lexicon might get weaker with age. A general increasing of grammatical difficulties also characterizes the linguistic production of older adults. This aspect as well may be associated with a general cognitive decline, affecting in particular short-term and working memory. The macrolinguistic dimension of linguistic production in older adults presents decreased levels of cohesiveness and both local and global coherence that, as for microlinguistic patterns, might not be simply due to a linguistic weakening but to a more general cognitive slowing. In particular, difficulties on narrative organization may be associated to the *inhibition deficit hypothesis* (Hasher & Zacks, 1988), revealing a minor ability for older adults to inhibit irrelevant information.

From a neurolinguistic point of view, several studies tried to support the hypothesis of neural changes in older adults' brains. They revealed reduced activation in areas involved in message production and lexical retrieval (Cabeza et al., 1997; Logan et al., 2002) and a general atrophy in neural networks implicated in lexical access (Stamatakis et al., 2011). Furthermore, some hypotheses have been formulated to interpret such findings (e.g., the HAROLD model, the PASA model and the Cognitive Reserve hypothesis). According to these hypotheses, the brain goes through major changes with aging. However, it also copes with these changes by reorganizing its neural connections and this has consequences on cognitive processing.

To summarize, older adults' linguistic production is influenced by a general cognitive decline as well as by physiological neural changes as a response to brain atrophy. It is important to take into account the typology of tasks used to elicit language production. In fact, sometimes results can be controversial because experiments are based on different administrations, aiming at assessing different features. In general, the use of ecological tests (such as procedures of discourse analysis) is desirable. Findings coming from neural investigations confirm the important role of neuroimaging techniques, which nowadays are fundamental for both research and clinical practice. However, further investigations are needed to deepen our understanding of the neural underpinnings and the cognitive characteristics of language production in the elderly.

## References

- Albert, M. L., Spiro, A., Sayers, K. J., Cohen, J. A., Brady, C. B., Goral, M., & Obler, L. K. (2009). Effects of health status on word finding in aging. *Journal of the American Geriatrics Society*, 57, 2300–2305. doi:10.1111/j.1532-5415.2009.02559.x
- Arbuckle, T. Y., & Gold, D. P. (1993). Aging, inhibition, and verbosity. *Journal of Gerontology*, 48(5), 225–232. doi:10.1093/geronj/48.5.P225
- Au, R., Joung, P., Nicholas, M., Obler, L. K., Kass, R., & Albert, M. L. (1995). Naming ability across the adult life span. *Aging and Cognition*, 2, 302–311.
- Badecker, W., Miozzo, M., & Zanuttini, R. (1995). The two stage model of lexical retrieval: Evidence from a case of anomia with selective preservation of grammatical gender. *Cognition*, 57, 193–216. doi:10.1016/0010-0277(95)00663-J
- Bowles, N. L., & Poon, L. W. (1985). Aging and retrieval of words in semantic memory. *Journal of Gerontology*, 40(1), 71–77. doi:10.1093/geronj/40.1.71
- Brown, R., & McNeill, D. (1966). The “tip of the tongue” phenomenon. *Journal of Verbal Learning and Verbal Behavior*, 5, 325–337. doi:10.1016/S0022-5371(66)80040-3
- Brown, A. S. (1991). A review of the tip-of-the-tongue experience. *Psychological Review*, 109, 204–223.

- Burke, D. M., MacKay, D. G., & James, L. E. (2000). Theoretical approaches to language and aging. In T. Perfect & E. Maylor (Eds.), *Models of cognitive aging* (pp. 204–237). Oxford: Oxford University Press.
- Burke, D. M., & Shafto, M. A. (2004). Aging and language production. *Current Directions in Psychological Science*, 13(1), 21–24. doi:10.1111/j.0963-7214.2004.01301006.x
- Cabeza, R., Grady, C. L., Nyberg, L., McIntosh, A. R., Tulving, E., Kapur, S., Jennings, J. M., Houle, S., & Craik, F. I. M. (1997). Age-related differences in neural activity during memory encoding and retrieval: A Positron Emission Tomography Study. *The Journal of Neuroscience*, 17(1), 391–400.
- Cabeza, R., Anderson, N. D., Locantore, J. K., & McIntosh, A. R., (2002). Aging gracefully: compensatory brain activity in high-performing older adults. *Neuroimage*, 17, 1394–1402. doi:10.1006/nimg.2002.1280
- Caplan, D. (1992). *Language: Structure, processing and disorders*. Cambridge, MA: The MIT Press.
- Capilouto, G., Wright, H. H., & Wagovich, S. (2005). CIU and main event analyses of the structured discourse of older and younger adults. *Journal of Communication Disorders*, 38(6), 431–444. doi:10.1016/j.jcomdis.2005.03.005
- Carpenter, P. A., Miyake, A., & Just, M. A. (1994). Working memory constraints in comprehension: Evidence from individual differences, aphasia, and aging. In M. A. Gernsbacher, (Ed.), *The handbook of psycholinguistics* (pp. 1075–1122). San Diego, CA: Academic Press.
- Catani, M., Dell'Acqua, F., Bizzi, A., Forkel, S. J., Williams, S. C., Simmons, A., Murphy, D. G., & Thiebaut de Schotten, M. (2012). Beyond cortical localisation in clinico-anatomical correlation. *Cortex*, 48(10), 1262–1287. doi:10.1016/j.cortex.2012.07.001
- Chomsky, N. (1995). *The minimalist program*. Cambridge, MA: The MIT Press.
- Clark, H. H. (1996). *Using Language*. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511620539
- Collette, F., Schmidt, C., Scherrer, C., Adam, S., & Salmon, E. (2007). Specificity of inhibitory deficits in adult aging and Alzheimer's disease. *Neurobiology of Aging*, 30, 875–889. doi:10.1016/j.neurobiolaging.2007.09.007
- Connor, L. (2001). Memory in old age: Patterns of decline and preservation. *Seminars in Speech and Language*, 22(2), 117–125. doi:10.1055/s-2001-13936
- Connor, L. T., Spiro, A., Obler, L. K., & Albert, M. L. (2004). Change in object naming ability during adulthood. *The Journals of Gerontology: Series B*, 59(5), 203–209. doi:10.1093/geronb/59.5.P203
- Damasio, H., Grabowski, T. J., Tranel, D., Hichwa, R., & Damasio, A. R. (1996). A neural basis for lexical retrieval. *Nature*, 380, 499–505. doi:10.1038/380499a0
- Davis, S. W., Dennis, N. A., Daselaar, S. M., Fleck, M. S., & Cabeza, R. (2008). Que PASA? The Posterior-Anterior Shift in aging. *Cerebral Cortex*, 18(5), 1201–1209. doi:10.1093/cercor/bhm155
- Davis, S. W., Dennis, N. A., Buchler, N. G., White, L. E., Madden, D. J., & Cabeza, R. (2009). Assessing the effects of age on long white matter tracts using diffusion tensor tractography. *Neuroimage*, 46, 530–541. doi:10.1016/j.neuroimage.2009.01.068
- Dell G. S. (1986). A spreading activation theory of retrieval and sentence production. *Psychological Review*, 93, 283–321 doi:10.1037/0033-295X.93.3.283
- Drag, L. L., & Bieliauskas, L. A. (2010). Contemporary review 2009: Cognitive aging. *Journal of Geriatric Psychiatry and Neurology*, 23, 75–93.

- Duchin, S. W., & Mysak, E. D. (1987). Disfluency and rate characteristics of young adult, middle-aged, and older males. *Journal of Communication Disorders*, 20, 245–257. doi:10.1016/0021-9924(87)90022-0
- Feyereisen, P. (1997). A meta-analytic procedure shows an age-related decline in picture naming: Comments on Goulet, Ska, and Kahn (1994). *Journal of Speech, Language, and Hearing Research*, 40(6), 1328–1333. doi:10.1044/jslhr.4006.1328
- Fiez, J. A., Raichle, M. E., Balota, D. A., Tallal, P., & Petersen, S. E. (1996). PET activation of posterior temporal regions during auditory word presentation and verb generation. *Cerebral Cortex*, 6, 1–10. doi:10.1093/cercor/6.1.1
- Fletcher, P. C., Happé, F., Baker, S. C., Dolan, R. J., Frackowiak R. S. J., & Frith, C. D. (1995). Other minds in the brain: A functional imaging study of “Theory of Mind” in story comprehension. *Cognition*, 57, 109–128. doi:10.1016/0010-0277(95)00692-R
- Fozo, M. S., & Watson, B. C. (1998). Task complexity effect on vocal reaction time in aged speakers. *Journal of Voice*, 12, 404–414. doi:10.1016/S0892-1997(98)80049-0
- Frazier L., & Fodor J. D. (1978). The sausage machine: A new two-stage parsing model. *Cognition*, 6, 291–325. doi:10.1016/0010-0277(78)90002-1
- Fromkin, V. A. (1971). The nonanomalous nature of anomalous utterances. *Journal of Linguistics*, 4, 47–68. doi:10.1017/S002222670000164X
- Garrett, M. (1975). The analysis of sentence production. In G. Bower (Ed.), *Psychology of learning and motivation* (Vol. 9). New York, NY: Academic Press.
- Garrett, M. F. (1980). Levels of processing in sentence production. In B. Butterworth (Ed.), *Language production: Speech and talk* (Vol. 1; pp. 177–220). London: Academic Press.
- Garrod, S., & Pickering, M. J. (2004). Why is conversation so easy? *Trends in Cognitive Sciences*, 8(1), 8–11. doi:10.1016/j.tics.2003.10.016
- Geschwind, N. (1970). The organization of language and the brain. *Science*, 170, 940–944. doi:10.1126/science.170.3961.940
- Ghisletta, P., & Lindenberger, U. (2003). Age-based structural dynamics between perceptual speed and knowledge in the Berlin Aging Study: direct evidence for ability dedifferentiation in old age. *Psychology and Aging*, 18, 696–713. doi:10.1037/0882-7974.18.4.696
- Glosser, G., & Deser, T. (1990). Patterns of discourse production among neurological patients with fluent language disorders. *Brain and Language*, 40(1), 67–88. doi:10.1016/0093-934X(91)90117-J
- Gold, D., & Arbuckle, T. Y. (1995). A longitudinal study of off-target verbosity. *Journal of Gerontology: Psychological Sciences*, 50B, 307–315. doi:10.1093/geronb/50B.6.P307
- Good, C. D., Johnsrude, I. S., Ashburner, J., Henson, R. N., Friston, K. J., & Frackowiak, S. J. (2001). A voxel based morphometric study of ageing in 465 normal adult human brains. *Neuroimage*, 14, 21–36. doi:10.1006/nimg.2001.0786
- Goral, M., Spiro, A. I., Albert, M. L., Oblor, L. K., & Connor, L. T. (2007). Change in lexical skills in adulthood: Not a uniform decline. *Mental Lexicon*, 2, 215–238. doi:10.1075/ml.2.2.05gor
- Goulet, P., Ska, B., & Kahn, H. J. (1994). Is there a decline in picture naming with advancing age? *Journal of Speech and Hearing Research*, 37(3), 629–644. doi:10.1044/jshr.3703.629
- Grady, C. L., & Craik, F. I. (2000). Changes in memory processing with age. *Current Opinions in Neurobiology*, 10, 224–231. doi:10.1016/S0959-4388(00)00073-8
- Grady, C. L., McIntosh, A. R., & Craik, F. I. (2003). Age-related differences in the functional connectivity of the hippocampus during memory encoding. *Hippocampus*, 13, 572–586.
- Green, D. W. (1986). Control, activation and resource. *Brain and Language*, 27, 210–223. doi:10.1016/0093-934X(86)90016-7

- Green, D. W. (1998). Mental control of the bilingual lexico-semantic system. *Bilingualism: Language and Cognition*, 1, 67–81. doi:10.1017/S1366728998000133
- Grice, H. P. (1975). Logic and conversation. In P. Cole, and J. P. Morgan (Eds.), *Syntax and semantics: Speech acts* (pp. 41–58). New York, NY: Academic Press.
- Griffin, Z. M., & Spieler, D. H. (2006). Observing the what and when of language production for different age groups by monitoring speakers' eye movements. *Brain and Language*, 99(3), 272–288. doi:10.1016/j.bandl.2005.08.003
- Grossman, M., Cooke, A., DeVita, C., Chen, W., Moore, P., Alsop, D., & Gee, J. (2002). Sentence processing strategies in healthy seniors with poor comprehension: An fMRI study. *Brain and Language*, 80, 296–313. doi:10.1006/brln.2001.2581
- Hagoort, P., Indefrey, P., Brown, C., Herzog, H., Steinmetz, H., & Seitz, R. J. (1999). The neural circuitry involved in the reading of German words and pseudowords: A pet study. *Journal of Cognitive Neuroscience*, 11, 383–398. doi:10.1162/089892999563490
- Hasher, L., & Zacks, R. T. (1988). Working memory, comprehension, and aging: A review and a new view. *Psychology of Learning and Motivation*, 22, 193–225. doi:10.1016/S0079-7421(08)60041-9
- Heller, R. B., & Dobbs, A. R. (1993). Age differences in word finding in discourse and nondiscourse situations. *Psychology and Aging*, 8, 443–450. doi:10.1037/0882-7974.8.3.443
- Hickok, G., Buchsbaum, B., Humphries, C., & Muftuler, T. (2003). Auditory-motor interaction revealed by fMRI: Speech, music, and working memory in area SPT. *Journal of Cognitive Neuroscience*, 15, 673–682. doi:10.1162/08989290322307393
- Indefrey, P., & Levelt, W. J. M. (2000). The neural correlates of language production. In M. S. Gazzaniga (Ed.), *The new cognitive neurosciences* (2nd ed.; pp. 845–865). Cambridge, MA: The MIT Press.
- Indefrey, P., & Levelt, W. J. M. (2004). The spatial and temporal signatures of word production components. *Cognition*, 92, 101–144. doi:10.1016/j.cognition.2002.06.001
- Indefrey, P. (2011). The spatial and temporal signatures of word production components: A critical update. *Frontiers in Psychology*, 2, 255. Epub 2011 Oct 12. doi:10.3389/fpsyg.2011.00255
- James, L. E., Burke, D. M., Austin, A., & Hulme, E. (1998). Production and perception of “verbosity” in younger and older adults. *Psychology and Aging*, 13, 355–367. doi:10.1037/0882-7974.13.3.355
- James, L. E., & Burke, D. M. (2000). Phonological priming effects on word retrieval and tip-of-the-tongue experiences in young and older Adults. *Journal of Experimental Psychology Learning Memory and Cognition*, 26, 1378–1391. doi:10.1037/0278-7393.26.6.1378
- James, L. E. (2004). Meeting Mr. Farmer versus meeting a farmer: Specific effects of aging on learning proper names. *Psychology and Aging*, 19, 515–522. doi:10.1037/0882-7974.19.3.515
- Johnson-Laird, P. N. (1980). Mental models in cognitive science. *Cognitive Science*, 4, 71–115. doi:10.1207/s15516709cog0401\_4
- Johnson-Laird, P. N. (1983). *Mental models: Toward a cognitive science of language, inference and consciousness*. Cambridge, MA: Harvard University Press.
- Juncos-Rabadán, O., Pereiro, A. X., & Rodríguez, M. S. (2005). Narrative speech in aging: Quantity, information content, and cohesion. *Brain and Language*, 95, 423–434. doi:10.1016/j.bandl.2005.04.001
- Kaplan, E., Goodglass, H., & Weintraub, S. (1983). *Boston naming test*. Philadelphia, PA: Lea and Febiger.
- Kemper, S., & Anagnopoulos, C. (1989). Language and ageing. *Annual Review of Applied Linguistics*, 10, 37–50. doi:10.1017/S0267190500001203

- Kemper, S. (1990). Adults' diaries: Changes to written narratives across the life span. *Discourse Processes*, 13, 207–223. doi:10.1080/01638539009544754
- Kemper, S., Herman, R. E., & Liu, C.-J. (2004). Sentence production by young and older adults in controlled contexts. *Journal of Gerontology: Psychological Sciences*, 59B, 220–224. doi:10.1093/geronb/59.5.P220
- Kemper, S., Greiner, L. H., Marquis, J. G., Prenovost, K., & Mitzner, T. (2001). Language decline across the life span: Findings from the Nun study. *Psychology and Aging*, 16, 227–239. doi:10.1037/0882-7974.16.2.227
- Kemper, S., & Sumner, A. (2001). The structure of verbal abilities in young and older adults. *Psychology and Aging*, 16, 312–322. doi:10.1037/0882-7974.16.2.312
- Kintsch, W. (1994). Text comprehension, memory, and learning. *American Psychologist*, 49, 294–303. doi:10.1037/0003-066X.49.4.294
- Kintsch, W., & van Dijk, T. (1978). Toward a model of text comprehension and production. *Psychological Review*, 85, 363–394. doi:10.1037/0033-295X.85.5.363
- Kuhl, P. K. (2010). Brain mechanisms in early language acquisition. *Neuron Review*, 67, 713–727. doi:10.1016/j.neuron.2010.08.038
- Levelt, W. J. M. (1989). *Speaking: From intention to articulation*. Cambridge, MA: The MIT Press.
- Levelt, W. J. M., Praamstra, P., Meyer A. S., Helenius, P., & Salmelin, R. (1998). A MEG study of picture naming. *Journal of Cognitive Neuroscience*, 10, 553–567. doi:10.1162/089892998562960
- Levelt, W. J. M., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences*, 22, 1–38.
- Levinson, S. C. (1983). *Pragmatics*. Cambridge: Cambridge University Press.
- Lindenberger, U., & Baltes, P. B. (1997). Intellectual functioning in old and very old age: Cross-sectional results from the Berlin Aging Study. *Psychology and Aging*, 12, 410–432. doi:10.1037/0882-7974.12.3.410
- Logan, J. M., Sanders, A. L., Snyder, A. Z., Morris, J. C., & Buckner, R. L. (2002). Under-recruitment and nonselective recruitment: Dissociable neural mechanisms associated with aging. *Neuron*, 33, 827–840. doi:10.1016/S0896-6273(02)00612-8
- Lyketsos, C. G., Chen, L. S., & Anthony, J. C. (1999). Cognitive decline in adulthood: An 11.5-year follow-up of the Baltimore Epidemiologic Catchment Area study. *American Journal of Psychiatry*, 156(1), 58–65. doi:10.1176/ajp.156.1.58
- MacKay, A., Connor, L. T., Albert, M. L., & Obler, L. K. (2002). Noun and verb retrieval in healthy aging. *Journal of the International Neuropsychological Society*, 8(1), 764–770. doi:10.1017/S1355617702860040
- Madden, D. J., Turkington, T. G., Provenzale, J. M., Denny, L. L., Hawk, T. C., Gottlob, L. R., & Coleman, R. E. (1999). Adult age differences in the functional neuroanatomy of verbal recognition memory. *Human Brain Mapping*, 7, 115–135. doi:10.1002/(SICI)1097-0193(1999)7:2<115::AID-HBM5>3.0.CO;2-N
- Marini A., Boewe A., Caltagirone, C. & Carlomagno, S. (2005). Age-related differences in the production of textual descriptions. *Journal of Psycholinguistic Research*, 34(5), 439–463. doi:10.1007/s10936-005-6203-z
- Marini, A., Andreetta, S., Del Tin, S., & Carlomagno, S. (2011a). A multi-level approach to the analysis of narrative language in aphasia. *Aphasiology*, 25(11), 1372–1392. doi:10.1080/02687038.2011.584690

- Marini, A., Galetto, V., Zampieri, E., Vorano, L., Zettin, M., & Carlomagno, S. (2011b). Narrative language in traumatic brain injury. *Neuropsychologia*, 49, 2904–2910. doi:10.1016/j.neuropsychologia.2011.06.017
- Marini, A., & Urgesi, C. (2012). Please, get to the point! A cortical correlate of linguistic informativeness. *Journal of Cognitive Neuroscience*, 24(11), 2211–2222. doi:10.1162/jocn\_a\_00283
- Marvel, C. L., Schwartz, B. L., & Isaacs, K. L. (2004). Word production deficits in Schizophrenia. *Brain and Language*, 89, 182–191. doi:10.1016/S0093-934X(03)00366-3
- Meinzer, M., Fleisch, T., Wilser, L., Eulitz, C., Rockstroh, B., Conway, T., Gonzalez-Rothi, L., & Crosson, B. (2009). Neural signatures of semantic and phonemic fluency in young and old adults. *Journal of Cognitive Neuroscience*, 21, 2007–2018. doi:10.1162/jocn.2009.21219
- Meunier, D., Stamatakis, E. A., & Tyler, L. K. (2014). Age-related functional reorganization, structural changes, and preserved cognition. *Neurobiology of Aging*, 35, 42–54. doi:10.1016/j.neurobiolaging.2013.07.003
- Miyake, A., Emerson, M. J., & Friedman, N. P. (2000). Assessment of executive functions in clinical settings: Problems and recommendations. *Seminars in Speech and Language*, 21, 169–183. doi:10.1055/s-2000-7563
- Mozeiko, J., Le, K., Coelho, C., Krueger, F., & Grafman, J. (2011). The relationship of story grammar and executive function following TBI. *Aphasiology*, 25, 826–835. doi:10.1080/02687038.2010.543983
- Nicholas, M., Obler, L., Albert, M. S., & Goodglass, H. (1985). Lexical retrieval in healthy aging. *Cortex*, 21, 595–606. doi:10.1016/S0010-9452(58)80007-6
- Norman, D. A., & Shallice, T. (1986). Attention to action: Willed and automatic control of behavior. In R. J. Davidson, G. E. Schwartz, & D. Shapiro (Eds.), *Consciousness and self-regulation: Advances in research and theory* (Vol. 4; pp. 1–18). New York, NY: Plenum. doi:10.1007/978-1-4757-0629-1\_1
- Obler, L. K., Au, R., Kugler, J., Melvold, J., Tocco, M., & Albert, M. L. (1994). Intersubject variability in adult normal discourse. In R. L. Bloom, L. K. Obler, S. D. Santi, & J. S. Ehrlich (Eds.), *Discourse analysis and applications. Studies in adult clinical population* (pp. 15–27). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Obler, L. K., Rykhlevskaia, E., Schnyer, D., Clark-Cotton, M. R., Spiro, A., Hyun, J., Kim, D. S., Goral, M., & Albert, M. L. (2010). Bilateral brain regions associated with naming in older adults. *Brain and Language*, 113(603), 113–123. doi:10.1016/j.bandl.2010.03.001
- Park, D. C., Welsh, R. C., Marshuetz, C., Gutchess, A. H., Mikels, J., Polk, T. A., Noll, D. C., & Taylor, S. F. (2003). Working memory for complex scenes: Age differences in frontal and hippocampal activations. *Journal of Cognitive Neuroscience*, 15, 1122–1134. doi:10.1162/08989290322598094
- Park, D. C., Polk, T. A., Park, R., Minear, M., Savage, A., & Smith, M. R. (2004). Aging reduces neural specialisation in ventral visual cortex. *Proceedings of the National Academy of Science*, 101, 13091–13095. doi:10.1073/pnas.0405148101
- Peelle, J. E., Chandrasekaran, K., Powers, J., Smith, E. E., & Grossman, M. (2013). Age-related vulnerability in the neural systems supporting semantic processing. *Frontiers in Aging Neuroscience*, 5, 46, 1–11. doi:10.3389/fnagi.2013.00046
- Persson, J., Ching-Yune, C., Sylvester, J. K., Nelson, J. K., Welsh, K. M., Jonides, J., & Reuter-Lorenz, P. A. (2004). Selection requirements during verb generation: differential recruitment in older and younger adults. *Neuroimage*, 23, 1382–1390. doi:10.1016/j.neuroimage.2004.08.004

- Pickering, M. J., & Garrod, S. (2004). Toward a mechanistic psychology of dialogue. *Behavioral and Brain Sciences*, 27(2), 169–190.
- Pratt, M. W., & Robins, S. L. (1991). That's the way it was: Age differences in the structure and quality of adults' personal narratives. *Discourse Processes*, 14, 73–85.  
doi:10.1080/01638539109544775
- Price, C. J., & Friston, K. J. (1997). Cognitive conjunctions: A new approach to brain activation experiments. *Neuroimage*, 5, 261–270. doi:10.1006/nimg.1997.0269
- Price, C. J., Indefrey, P., & van Turenout, M. (1999). The neural architecture underlying the processing of written and spoken word forms. In C. M. Brown & P. Hagoort (Eds.), *The Neurocognition of language* (pp. 211–240). Oxford: Oxford University Press.
- Radvansky, G. A., Gerard, L. D., Zacks, R. T., & Hasher, L. (1990). Younger and older adults' use of mental models as representations for text materials. *Psychology and Aging*, 5, 209–214.  
doi:10.1037/0882-7974.5.2.209
- Radvansky, G. A., Copeland, D. E., & Zwaan, R. A. (2003). Aging and functional spatial relations in comprehension and memory. *Psychology and Aging*, 18, 161–165.  
doi:10.1037/0882-7974.18.1.161
- Rastle, K. G., & Burke, D. M. (1996). Priming the tip of the tongue: Effects of prior processing on word retrieval in young and older adults. *Journal of Memory and Language*, 35, 585–605. doi:10.1006/jmla.1996.0031
- Raz, N., Lindenberger, U., Rodrigue, K. M., Kennedy, K. M., Head, D., Williamson, A., Dahle, C., Gerstorf, D., & Acker, J. D. (2005). Regional brain changes in aging healthy adults: General trends, individual differences and modifiers. *Cerebral Cortex*, 15, 1676–1689.  
doi:10.1093/cercor/bhio44
- Resnick, S. M., Pham, D. L., Kraut, M. A., Zonderman, A. B., & Davatzikos, C. (2003). Longitudinal magnetic resonance imaging studies of older adults: a shrinking brain. *Journal of Neuroscience*, 23, 3295–3301.
- Riecker, A., Mathiak, K., Wildgruber, D., Erb, M., Hertrich, I., Grodd, W., & Ackerman H. (2005). fMRI reveals two distinct cerebral networks subserving speech motor control. *Neurology*, 64, 700–706. doi:10.1212/01.WNL.0000152156.90779.89
- Risse, G. L., Gates, J. R., & Fangman, M. C. (1997). A reconsideration of bilateral language representation based on the intracarotid amobarbital procedure. *Brain and Cognition*, 33, 118–132. doi:10.1006/brcg.1997.0887
- Sach, M., Seitz, R. J., & Indefrey, P. (2004). Unified inflectional processing of regular and irregular verbs: A PET study. *Neuroreport*, 15(3), 533–537. doi:10.1097/00001756-200403010-00030
- Salthouse, T. A. (1996). Constraints on theories of cognitive aging. *Psychology and Aging*, 3, 287–299.
- Schmahmann, J. D., & Pandya, D. N. (1997). The cerebro-cerebellar system. *International Review of Neurobiology*, 41, 31–60. doi:10.1016/S0074-7742(08)60346-3
- Schneider, B. A., Daneman, M., Murphy, D. R., & See, S. K. (2000). Listening to discourse in distracting settings: The effects of aging. *Psychology and Aging*, 15, 110–125.  
doi:10.1037/0882-7974.15.1.110
- Schneider, B. A., Daneman, M., & Pichora-Fuller, M. K. (2002). Listening in aging adults: From discourse comprehension to psychoacoustics. *Canadian Journal of Experimental Psychology*, 56, 139–152. doi:10.1037/h0087392
- Schmitter-Edgecombe, M., Vesneski, M., & Jones, D. W. (2000). Aging and word-finding: A comparison of spontaneous and constrained naming tests. *Archives of clinical neuropsychology: The official journal of the National Academy of Neuropsychologists*, 15(6), 479–493.

- Schroeder, D. H., & Salthouse, T. A. (2004). Age-related effects on cognition between 20 and 50 years of age. *Personality and Individual Differences*, 36, 393–404.  
doi:10.1016/S0191-8869(03)00104-1
- Shadden, B. (1997). Discourse behaviours in older adults. *Seminar in Speech and Language*, 18(2), 156–147. doi:10.1055/s-2008-1064069
- Sharp, D. J., Scott, S. K., Mehta, M. A., & Wise, R. J. S. (2006). The neural correlates of declining performance with age: Evidence for age-related changes in cognitive control. *Cerebral Cortex*, 16, 1739–1749. doi:10.1093/cercor/bhj109
- Ska, B., Scherer, L. C., Flores, O. C., de Oliveira, C. R., Netto, T. M., & Fonseca, R. P. (2009). Theoretical, behavioral and neuroimaging evidence on discourse processing in aging. *Psychology and Neuroscience*, 2, 101–109. doi:10.3922/j.psns.2009.2.002
- Soros, P., Bose, A., Sokoloff, L. G., Graham, S. J., & Stuss, D. T. (2011). Age-related changes in the functional neuroanatomy of overt speech production. *Neurobiology of Aging*, 32(8), 1505–1513.
- Sperber, D., & Wilson, D. (1986). *Relevance. Communication and cognition*. Oxford: Blackwell.
- Stamatakis, E. A., Shafto, M. A., Williams, G., Tam, P., & Tyler, L. K. (2011). White matter changes and word finding failures with increasing age. *PlosOne*, 6(1), e14496.  
doi:10.1371/journal.pone.0014496
- Stern, Y. (2009). Cognitive reserve. *Neuropsychologia*, 47, 2015–2028.  
doi:10.1016/j.neuropsychologia.2009.03.004
- Thornton, R., Skovbrotten, K., & Burke, D. M. (2004). Grammatical agreement processes in young and older adults. Presented at the *Forty-Fifth Annual Meeting of the Psychonomic Society*. Minneapolis, MN.
- Thornton, R., & Light, L. L. (2006). Language comprehension and production in normal aging. In J. E. Birren & Schaie K.W. (Ed.), *Handbook of the psychology of aging* (pp. 261–287). San Diego CA: Academic Press. doi:10.1016/B978-012101264-9/50015-X
- Tremblay, P., Deschamps, I., & Gracco, V. (2013). Regional heterogeneity in the processing and the production of speech in the human planum temporale. *Cortex*, 49(1), 143–157.
- Trunk, D. L., & Abrams, L. (2009). Do younger and older adults' communicative goals influence off-topic speech in autobiographical narratives? *Psychology and Aging*, 24(2), 324–337.  
doi:10.1037/a0015259
- Tucker, F. M., & Hanlon, R. E. (1998). Effects of mild traumatic brain injury on narrative discourse production. *Brain Injury*, 12, 783–792. doi:10.1080/026990598122179
- Tyler, L. K., Shafto, M. A., Randall, B., Wright, P., Marslen-Wilson, W. D., & Stamatakis, E. A. (2010). Preserving syntactic processing across the adult life span: The modulation of the frontotemporal language system in the context of age related atrophy. *Cerebral Cortex*, 20, 352–364. doi:10.1093/cercor/bhp105
- Ulatowska, H. K., Hayashi, M. M., Cannito, M. P., & Fleming, S. G. (1986). Disruption of reference in aging. *Brain and Language*, 28(1), 24–41. doi:10.1016/0093-934X(86)90088-X
- Ullman, M. T. (2001). The declarative/procedural model of lexicon and grammar. *Journal of Psycholinguistic Research*, 30(1), 37–69. doi:10.1023/A:1005204207369
- Ullman, M. T. (2004). Contributions of memory circuits to language: The declarative/procedural model. *Cognition*, 92, 231–270. doi:10.1016/j.cognition.2003.10.008
- Verhaeghen, P. (2003). Aging and vocabulary score: A meta-analysis. *Psychology and Aging*, 18, 332–339. doi:10.1037/0882-7974.18.2.332

- Verhaegen, C., & Poncelet, M. (2012). Changes in naming and semantic abilities with aging from 50 to 90 years. *Journal of the International Neuropsychological Society*, 19, 119–126. doi:10.1017/S1355617712001178
- Vigliocco, G., Garrett, M. F., & Antonini, T. (1997). Grammatical gender is on the tip of Italian tongues. *Psychological Science*, 8, 314–317. doi:10.1111/j.1467-9280.1997.tb00444.x
- Vigneau, M., Beaucousin, V., Hervé, P. Y., Duffau, H., Crivello, F., Houdé, O., Mazoyer, B., & Tzourio-Mazoyer, N. (2006). Meta-analyzing left hemisphere language areas: Phonology, semantics, and sentence processing. *Neuroimage*, 30, 1414–1432. doi:10.1016/j.neuroimage.2005.11.002
- Wager, T. D., Jonides, J., & Reading, S. (2004). Neuroimaging studies of shifting attention: A meta-analysis. *Neuroimage*, 22, 1679–1693.
- Wierenga, C. E., Benjamin, M., Gopinath, K., Perlstein, W. M., Leonard, C. M., Rothi, L. J., Conway, T., Cato, M. A., Briggs, R., & Crosson, B. (2008). Age-related changes in word retrieval: role of bilateral frontal and subcortical networks. *Neurobiology of Aging*, 29, 436–451. doi:10.1016/j.neurobiolaging.2006.10.024
- Wills, C. L., Capilouto, G. J., & Wright, H. H. (2012). Attention and off-topic speech in the recounts of middle-age and elderly adults: A pilot investigation. *Contemporary Issues in Communication Sciences & Disorders*, 39, 105–112.
- Wingfield, A., & Stine-Morrow, E. A. L. (2000). Language and speech. In F. I. M. Craik & T. A. Salthouse (Eds.), *Handbook of aging and cognition* (2nd ed.; pp. 359–416). Mahwah, NJ: Lawrence Erlbaum Associates.
- Wingfield, A., & Tun, P. (2001). Spoken language comprehension in older adults: Interactions between sensory and cognitive change in normal aging. *Seminars in Hearing*, 22(3), 287–301. doi:10.1055/s-2001-15632
- Ylvisaker, M., Szekeres, S. F., & Feeney, T. (2001). Communication disorders associated with traumatic brain injury. In R. Chapey (Ed.), *Language intervention strategies in aphasia and related neurogenic communication disorders* (pp. 745–800). Baltimore, MD: Williams and Wilkins.
- Zacks, R. T., & Hasher, L. (1997). Cognitive gerontology and attentional inhibition: A reply to Burke and McDowd. *Journal of Gerontology: Psychological Sciences*, 52B, 274–283. doi:10.1093/geronb/52B.6.P274
- Zwaan, R. A., & Radvansky, G. A. (1998). Situation models in language comprehension and memory. *Psychological Bulletin*, 123, 162–185. doi:10.1037/0033-2909.123.2.162



## Aging effects on discourse production

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Discourse is defined as any language “beyond the boundaries of isolated sentences” (Ultowska & Olness, 2004, p. 300), and it allows people to do things together; tease each other, build things, share feelings, and make plans for the future. Yet discourse requires more than simply generating a continuous stream of linguistic elements. Discourse production requires both within-sentence (i.e. microlinguistic) elements and processes that are traditionally associated with the field of linguistics (e.g. phonemes & syntax) as well as between-sentence elements and processes to produce a coherent message. In this chapter, we focus on how this delicate balance between micro- and macrolinguistic processes change and are maintained within discourse as people age. To do this, we initially review the interactive-construction model of discourse. Next, we review micro- and macrolinguistic processes within aging research. For microlinguistic, we focus on lexical diversity, which can be defined as the range of vocabulary used by a person within a discourse sample. For the macrolinguistic process, we focus on coherence, which can be defined as how discourse is connected and organized beyond the grammar of a sentence. For both lexical diversity and coherence, we review common analysis techniques, what occurs to these processes as we age, and the cognitive and linguistic systems that underpin these aspects of discourse. Finally, we conclude the chapter by highlighting areas of future research within lexical diversity and coherence research that are important to understanding discourse as people age.

### Aging effects on discourse production

Imagine meeting a friend at a café. She arrives late and does not greet you or even ask you how you are doing. Instead, she jumps directly into the middle of a story:

- (1) I had to stop to ask this man. You know, I hate how the roads are laid out in this city. It is just terrible. I saw this man just standing on the side of the road. I think he was planting a tree. I'm not sure. He might have been a city worker

or business owner. I stopped. I pulled over. I was driving. By the way, my car is making a funny noise, but I'll tell you more about that later. I asked this man for directions. He told me to turn right on Bright Street, so here I am.

Throughout her story, the speaker continually jumps around, sharing with the audience the story's climax before stating what the problem was. Clearly, such a narrative would fail to convey the intended message without further clarification. To make matters worse, the speaker interjects what appear to be unrelated topics (e.g. her car problems). In fact, half of her story is off-topic. These off-topic comments cause the audience more difficulty in following and interpreting her intended message.

The story conveyed is an example of one type of discourse. Discourse production requires more than simply generating a continuous stream of linguistic elements. It requires different stages of processing, and it requires the within-sentence (i.e. microlinguistic) units and processes that are traditionally associated with the field of linguistics. These include the sounds and meanings that make-up words and how the words are arranged within a sentence. Difficulty in comprehending the above story is not due to grammatical errors; each utterance is constructed following syntactic rules. Discourse also includes between-sentence (i.e. macrolinguistic) processes that govern how utterances are arranged into a coherent message. To successfully navigate discourse, both the microlinguistic and macrolinguistic elements must be arranged into a structure that conveys the intended message to the audience and is appropriate for the situation. It is this collection of elements "beyond the boundaries of isolated sentences" (Ulatowska & Olness, 2004, p. 8), which differentiates successful discourse from randomly generated utterances; and, it is at the level beyond the utterance, the macrolinguistic level, as to why a breakdown in communication may occur between the speaker of the above story and the listener.

For this chapter, several discourse models and prototypical forms of discourse (i.e. narrative discourse, evencasts, and recounts) that are commonly used during social interactions are overviewed. Next, the chapter focuses on how cognitive changes during the aging process affect discourse production in older adults. These include micro- and macrolinguistic processes, specifically lexical diversity and coherence, respectively. Finally, future directions for research are suggested.

## **Interactive-construction model of discourse**

Researchers use discourse models to formalize and test their understanding of how discourse is processed and understood by individuals. Several models of discourse have been developed that focus on different aspects of the processes that

underlie language production and comprehension. Of particular interest is the interactive-construction model created by Kintsch and van Dijk (1978).

Kintsch and van Dijk (1978) completed the seminal work in integrative discourse processing, and their model serves as the foundation for much of the research in this area. They describe discourse structure as requiring four levels of representation. Unique to this model is that all discourse genres are considered. The first level (*surface*) includes traditional linguistic units such as phonemes and morphemes as well as word combinations that lead to the sentences. The second level (*semantic*) represents the concepts expressed and the links between them. A *proposition* is the smallest semantic unit and is typically a predicate with one or more arguments (i.e., verb or preposition plus noun). The third level (*situational*) is the relations among concepts that represent the situations and/or events depicted. The fourth level (*structural*) is the organization of the concept units, represented sequentially and/or temporally. At this level the structure of the discourse is identified, for example the script for a procedure. The basis of integrative discourse models, like that of Kintsch and van Dijk's, is that several cognitive operations are involved at each level of representation. However, cognitive processes are descriptively implicated and not specifically identified. Van Dijk (1997) described the integration of language and cognition when describing three main dimensions of discourse: language use (referred to as verbal structure by Stemmer, 1999); cognition (referred to as communication of beliefs by Stemmer, 1999); and action and interaction in social situations (i.e., pragmatics, conversation). Though these dimensions are assumed to be interrelated and influence one another (Kintsch, 1998; Stemmer, 1999; van Dijk, 1997), the specific operations and processes remain elusive.

The core of Kintsch and van Dijk's (1978) model is realized within two stages. First, the utterances are produced with propositional links between them. These propositional links are called micro-propositions. Secondly, the micro-propositions held within short-term memory for enough time and often with repeated exposure begin a generalization processes that produces a gist proposition within long-term memory. The gist propositions are not related to the links between utterances but the overall gist of the discourse. Kintsch and van Dijk (1978) called these propositions macro-propositions.

Micro-propositions are illustrated in example (11a) and (11b):

- (11) a. Erica drove the car.  
 b. The car was going fast.

Utterances (11a) and (11b) may be represented as having the micro-propositions in (12a) and (12b):

- (12) a. Drove (agent: ERICA, object: CAR).  
 b. Going (Theme: Car, Manner: Fast)

In the Interactive-Construction (IC) model, these micro-propositions are constructed directly from utterances on the basis of lexical information stored in memory. As they enter short-term or working memory, micro-propositions are hierarchically and temporally organized. Since short-term memory is limited, only a few micro-propositions are held within memory as the next cycle begins processing. If at any time, the next utterance into working memory does not share any relations with the micro-proposition stored within memory, the listener must search long-term memory (i.e. their world knowledge) to make an inference about the relations between the text and the sentence (Kintsch & van Dijk, 1978). For utterances (11a) and (11b), the concept CAR is a link between them.

Of course, to understand a narrative, a listener requires more than a hierarchical list of relationships between the semantic elements of a story. These macro-propositions create a global, hierarchical structure of the main themes needed to understand a story. These macro-propositions are created in parallel with the micro-propositions and represent the world knowledge and strategies that the listener uses to decide what to keep and what to discard (Kintsch, 1994). Macro-propositions are formed by a series of semantic mapping rules. These rules reduce and organize the information of the story to a manageable level for the listener. Kintsch and van Dijk (1978) describes three semantic mapping rules for macro-propositions:

1. Deletion: propositions that have no connection, direct or indirect, to a previous proposition will be deleted
2. Generalization: propositions can be replaced by more general propositions
3. Construction: propositions can be replaced by conventionalized facts.

While the IC model describes the general cognitive process and provides general rules for how discourse is processed and comprehended, the model only describes these cognitive systems in relation to the four levels of representation. The model does not specify how these cognitive systems function to produce discourse comprehension or production. For example, in Kintch and van Dijk (1978), they limit the working memory to four micro-propositions per cycle.

To illustrate why example (1) is difficult to comprehend in relation to IC model, consider the number of non-linking utterances. Two utterances from example (1) are reproduced here as (15a) and (15b).

- (15) a. I had to stop to ask this man.  
 b. You know, I hate how the roads are laid out in this city.

In (15a), there is the micro-proposition: *stop(agent: I)* and *ask(agent I, object: man)*. Yet (15b) does not contain any information related to (15a), except the ego-centric use of *I*. Therefore, to try and understand the story, the listener must search long-term memory for a connection between utterances (15a) and (15b). The global concepts needed to understand the gist of the story are not directly stated; instead, the listener has to make inferences. For the above example, the listener can assume that the speaker is on the road, hence her immediate dislike of it, and has to stop and ask a man for direction because of the terrible road system. This inferencing is cognitively more difficult than generalizing directly from lexical items present in the discourse sample.

Age related changes in discourse production and comprehension are often not related to microlinguistic aspects. As in example (1), healthy older adults still produce grammatical, well-formed utterances, though with an increase in grammatical errors compared with younger adults (Marini et al., 2005). Like example (1), the difficulty for many older adults is in organizing discourse and inhibiting tangential, unrelated content from entering the discourse sample. The rest of the chapter will discuss how microlinguistic and macrolinguistic abilities manifest in the discourse of older adults.

### **Microlinguistic analysis**

Microlinguistic analyses focus on the within-sentence linguistic elements of language, which include the phonological, lexical, morphological, and syntactic aspects of discourse (Brownell, 1988). Some microlinguistic measures are documented to change with age. Older adults often experience more word-finding difficulties compared to younger adults (Albert et al., 2009; Connor et al., 2004; Griffin & Spieler, 2006; see Chapter 7 for more information). Measures of grammatical processing are also well documented to decline with age. Older adults produce fewer complex utterances compared to younger adults (Kemper, Marquis, & Thompson, 2001; Kemper & Sumner, 2001; Marini et al., 2005; Shadden, 1997) and produce more errors related to morphological and syntactic processing (Marini et al., 2005). These declines appear to be a result of a decline in working memory (Kemper & Sumner, 2001; see Chapter 2 for more information). However, many microlinguistic processes are more resistant to age-related changes than macrolinguistic processes (e.g. coherence). Lexical diversity is one of the microlinguistic measures demonstrated to be resistant to age related decline (Cooper, 1990; Fergadiotis et al., 2011; Kemper & Sumner, 2001). The next section focuses on lexical diversity to provide an example of how language does not change with age and, perhaps, even improves with age. Further examined is the importance of

lexical diversity within discourse and summary of the research on aging and lexical diversity.

## Lexical diversity

Our lexicon is an important aspect of communication. It is the building block of discourse, and without access to a diverse vocabulary, the capacity of an individual to communicate effectively may be reduced. Moreover, a larger vocabulary is associated with higher quality stories in both verbal and written forms (Yu, 2009). Understanding the knowledge and processes that make vocabulary possible is necessary to understand lexical diversity (LD). Chapelle (1994) defined a model of vocabulary that included four domains:

1. The number of words stored by an individual
2. The knowledge of the phonology, semantics, and pragmatics of words
3. The organization of words within memory
4. Cognitive processes associated with word retrieval

Within this model, LD is more closely associated with the number of words stored by an individual (Fergadiotis, 2011). This is because LD can be thought of as an estimate of an individual's vocabulary size within a specific context. However, the cognitive processes that access and retrieve words are also important for LD. Retrieval deficits found in participants with aphasia (PWA) illustrate this point. PWA may have a preserved word storehouse but they have difficulty accessing these words (McNeil & Pratt, 2001). This reduced access lowers measures of LD in PWA. Inherent in this model is the understanding that language depends on both implicit knowledge of language (e.g. size of lexicon) and the capacity of language (e.g. retrieval of lexicon; see Chomsky, 1980). Both knowledge and capacity affect LD. LD is a measure of language knowledge and performance. LD can be defined as the range of vocabulary used by an individual within a discourse sample that reflects the size of an individual's lexicon and the retrieval processes employed by the individual (Fergadiotis & Wright, 2011).

## Measuring lexical diversity

There are several ways to estimate LD: number of different words (NDW); type-token ratio (TTR; Chotlos, 1944); Guiraud index (Guiraud, 1960); Maas's index (Maas, 1972); D (Malvern & Richards, 1997); and the measure of textual lexical diversity (MTLD; McCarthy, 2005). At their core, these estimates of LD count the

number of unique words produced within a discourse sample, which, in turn, are used to estimate the vocabulary knowledge of an individual (Fergadiotis & Wright, 2011). However, measuring LD is not straightforward (Fergadiotis, 2011; Fergadiotis, Wright, & West, 2013; Koizumi & In'nami, 2012), and many of these methods employ sophisticated techniques to correct for problems like sample length. A review of the different types of LD measures follows.

**Type-token ratio (TTR)** and **Number of Different Words (NDW)** are the most common estimates of LD (Chotlos, 1944; Templin, 1957). NDW is a count of the number of unique words produced within a discourse sample. The method provides a straightforward quantitative assessment of LD, but it requires sample length to be similar across all participants because on average longer samples have a greater likelihood of having more unique words. To combat this problem, TTR counts the number of unique words (types) and divides it by the total number of words (tokens [Chotlos, 1944]). Ratios closer to 0 reflect less diversity in vocabulary, whereas scores closer to 1 reflect greater diversity. Yet, this method suffers from sample length effects as well. According to Heap's law (1978), as a discourse sample gets longer, the likelihood of encountering a new word decreases compared to the number of already used words (i.e. non-unique words) being added to the transcript. Therefore, the number of already used words will increase faster than the number of newly added words. So TTR has the opposite problem from NDW. As the sample gets longer, words will be added, but very few words will be new items. Since TTR is the number of new words divided by total words, longer samples can seem less diverse than shorter samples.

**Guiraud** and **Maas** are two methods that researchers employed to solve the problem of sample length (Koizumi & In'nami, 2012). The methods employ mathematical transforms of TTR. Guiraud (1960) took the square root of tokens and divided word types by the square-root of the tokens ( $\text{Types}/\sqrt{\text{Tokens}}$ ). Maas (1972) applied a log transformation, where the log of the types was divided by the log of the tokens ( $\log[\text{types}]/\log[\text{tokens}]$ ). Yet several researchers have found that these mathematical transformations covary with length (Jarvis, 2002; Malvern & Richards, 1997; Tweedie & Baayen, 1998). These mathematical transformations did little to solve the problems associated with length.

**D** and **MTLD** are more sophisticated calculations that require special software (Koizumi & In'nami, 2012). **D**, first developed by Malvern and Richards (1997), combines random sampling with curve fitting to estimate LD. It is based on the idea that TTR will decrease as sample length increases. For samples with a more diverse vocabulary, TTR will decrease more slowly than for samples with a less diverse vocabulary. To estimate **D** for a sample, 35 tokens are sampled randomly from the text without replacement. For this sample, TTR is estimated. This process is repeated 100 times. Then, samples of 36 to 50 tokens are taken from the

text. The TTR ratio of these samples are plotted to form an empirical curve. Then, *D* uses the least squares approach to solve a formula that maximizes the fit to the empirical TTR curve (McKee, Malvern, & Richards, 2000). Finally, the entire process is run three times, and an average of the three runs serves as the final *D*.

Several researchers have investigated the validity of *D* scores (Durán, Malvern, Richards, & Chipere, 2004; Fergadiotis & Wright, 2011; Koizumi & In'nami, 2012). However, there are two main criticisms of *D*: (1) language samples require at least 50 tokens and (2) lexical items are randomly sampled. For the first issue, Koizumi and In'nami (2012) found that the requirement for 50 plus tokens removed around 27% of their samples from analysis. Moreover, these samples were more likely to have lower LD scores. This biases the mean of *D* scores upward, which suggest *D* scores are affected, somewhat, by sample length. This positive bias may be a significant problem in some cases given that it generates missing data not at random (Fergadiotis et al., 2013). In regards to (2), Jarvis (2002) claimed that random sampling ignores word order. The sample is treated as a series of discrete units, which is contradictory with discourse models that claim individuals form intact mental representations based on the structure (i.e. word order) of the text (Kintsch & van Dijk, 1978).

MTLD, first developed by McCarthy (2005), tackles the problems associated with sample length and random sampling. It analyzes sequential word strings in a sample until the sample reaches a certain TTR (i.e., .72). When the TTR of .72 is reached, a factor count is increased by one. The process starts again until the end of the sample is reached. Then, the tokens are divided by the factor. The same procedure is repeated by starting at the end of the text and moving to the beginning. These two numbers are averaged together to determine the MTLD score (Fergadiotis et al., 2013; Koizumi & In'nami, 2012; McCarthy, 2005). Researchers have consistently found that MTLD is a reliable measure of LD. Fegadiotis et al. (2013) found MTLD to have little association with sample length and had relatively small variances, which demonstrates the score's validity. Koizumi and In'nami (2012) also found MTLD to be the least affected by sample length. However, the researchers caution using MTLD in samples of less than 100 tokens.

## Lexical diversity in older adults

There is evidence that older adults' vocabulary increases until their mid to late 60s (Albert, Heller, & Milberg, 1988; Schaie & Willis, 1993) and some evidence that lexical access is somewhat preserved (LaBarge, Edwards, & Knesevich, 1986). Yet the inability to recall certain words does increase with age (see Chapter 7). However, most research in the area of LD and older adults deals with single concepts.

In these studies, older adults have been required to produce definitions (Wechsler, 1981) or name pictures (Howard & Patterson, 1992; Kaplan, Goodglass, & Weintraub, 2001). Few researchers have investigated LD at the discourse level (Cooper, 1990; Fergadiotis, Wright, & Capilouto, 2011; Kemper & Sumner, 2001; Kemper, Schmalzried, Hoffman, & Herman, 2010). For single concept naming, lexical access is a relatively straightforward process. The individual will see the picture and access both a network of semantic features and a set of phonological units (Shelley-Tremblay, 2011). For discourse, Kintsch (1994) claims that the process not only requires accessing both phonological and semantic networks, but maintaining a set of utterances within working memory (i.e. local coherence) and maintaining the overall gist of the discourse (i.e. global coherence). This makes accessing words within discourse more complicated.

Despite the relative difficulty of discourse, Fergadiotis et al. (2011) demonstrated higher LD as indicated by D for older adults in both procedural and recount tasks. Kemper and Sumner (2001) also found that older adults had higher LD as indicated by TTR for a five-minute informal interview. Fergadiotis et al. (2011) and Kemper and Sumner's (2001) results agree with single concept research that found older adults have larger vocabularies (Albert, Heller, & Milberg, 1988; Schaie & Willis, 1993) with preserved access to lexical items (LaBarge, Edwards, & Knesevich, 1986). However, Cooper (1990) found no significant difference in LD as indicated by TTR and NDW between younger and older adults in a picture description task. To date, no researcher has reported that LD significantly declines with age within a discourse elicitation task. These results may be explained by sample length and discourse type. Overall, LD appears to be resistant to age related changes.

Kemper and Sumner (2001) used TTR to estimate LD in younger and older adults. They elicited 5-minute recounts from 100 younger (18 to 28 years old) and 100 older (63 to 88 years old) adults. Participants also completed measures of working memory, processing speed, and verbal fluency. Kemper and Sumner found an age effect for TTR that favored the older adults. In contrast, Cooper (1990) found no correlation between age and LD measures – NDW or TTR. Cooper included 80 adults (42 females) between the ages of 20 and 78. The participants were well educated ( $M$  years of education = 15.71,  $SD$  = 2.82) with an above-average socioeconomic status. The discourse samples elicited were single picture descriptions and included the Cookie Theft (Goodglass & Kaplan, 1976) and two additional single pictures. Cooper examined several variables important for understanding lexical diversity, which includes total words, total time, NDW, and TTR. Cooper found that LD and total words produced was resistant to age-related changes.

Cooper (1990) and Kemper and Sumner (2001) both used TTR as estimates for LD, which makes their results unreliable since sample length was not controlled.

Kemper and Sumner, who concluded that older adults have more diverse vocabularies, found that their younger adults produced longer discourse samples. TTR is typically larger for shorter samples compared to longer samples; these results may not accurately reflect vocabulary diversity for the older participants. Cooper (1990), who found no difference between younger and older adults, also found no significant differences between total number of words and total time between the younger and older adults. Therefore, Cooper's results might more accurately reflect the LD abilities of older adults since sample length was not a confounding variable.

Fergadiotis et al. (2011) found age effects for LD and discourse type. The study included 43 younger adults (20–29 years old) and 43 older adults (70–79 years old). The mean age for the younger group was 23.00 years, and the mean age for the older group was 75.28 years. The groups were matched for gender and education. The participants told stories for four discourse types: single pictures, wordless storybooks, procedures and recounts. For the stimuli with pictures, the single pictures included line drawings. The wordless storybook included *Picnic* (McCully, 1984). For recounts participants told what they did last weekend, on their last vacation, and last holiday. The procedural discourse included how to make a peanut butter sandwich and how to plant a flower. D was used to estimate lexical diversity. Fergadiotis and colleagues did not find a significant difference between age groups for the discourse samples that were elicited using pictured stimuli. However, for the procedural discourse task and the recounts task, the older adults had a significantly higher LD than the younger adults.

Fergadiotis et al. (2011) concluded that LD may be influenced by discourse type. For the discourse elicitation tasks that employed pictures (picture descriptions and wordless picture book), the stimuli may have provided sufficient scaffolding of the story structure to support the narrative produced by the younger but also constrained the older adults' production. This resulted in a non-significant difference between the groups. Alternatively, the non-pictorial stimuli's (e.g. procedural and recount discourse task) open nature may allow more freedom in choosing lexical items. This resulted in a significant difference between the groups because the older adults have larger lexical stores on which to draw upon.

**Table 1.** Lexical diversity difference between younger and older adults for discourse types

Discourse type	Lexical diversity
Recounts	Higher in older adults
Procedural	Higher in older adults
Eventcast	No difference
Storytelling	No difference

Possibly, these findings can partly account for the results of previous researchers who found no difference between younger and older adults (Cooper, 1990). Kemper and Sumner (2001) did not use pictured stimuli to elicit discourse samples from their younger and older participants, and they found differences in LD that favored older adults, whereas, Cooper (1990) used single picture elicitation tasks and found no differences between age groups.

### Lexical diversity and cognition

According to Kintsch and van Dijk (1978), the surface level of discourse is subserved by the cognitive systems of working memory and executive function. Both working memory (Salthouse & Babcock, 1991) and executive function (Hasher & Zacks, 1988) decline with age, which results in word-retrieval difficulties in older adults (see Chapter 2). Yet semantic memory, the store-house of words and world knowledge, is preserved well into the oldest old (Albert, Heller, & Milberg, 1988; Schaie & Willis, 1993). While older adults might take longer to produce discourse samples, their ability to produce lexical items within discourse does not seem to decline. Therefore, older adults are able to produce accurate and informative discourse samples at the surface level, which will be processed in the manner discussed above in the IC model.

Unfortunately, how LD relates to the other levels of representation within the IC model is not specified. While it is known that disruptions in lexical diversity impact later stages of discourse processing (Wright & Capilouto, 2012), the impact of a larger vocabulary on the later stages of discourse processing have not been examined. Moreover, researchers have not examined if the larger vocabularies found in older adults provide any benefit to later stages of discourse organization and processing. Christiansen (1995) suggested that people with aphasia have difficulties with later stages of discourse processing because of their inability to produce specific words required by discourse context. It is therefore possible that the larger vocabularies have the opposite effect and provide a benefit to the later stages of discourse processing.

Unfortunately, it difficult to draw conclusions in LD research. For example, LD has been discussed as reflecting a large vocabulary, yet it is just as likely that the stable or higher LD scores found in some studies (e.g., Fergadiotis et al., 2011; Kemper & Sumner, 2001) reflect an increase in words not related to the content of the stimuli (fillers, tangential utterances, etc.) that can impede understanding. Refer back to the story in example (1); the story contains words that the person has learned and can access. However, the discourse contains macrolinguistic errors that influence LD. The discourse sample includes many off-topic utterances

that could increase the overall LD of the sample. For example, in (14a) below, the person includes the words “funny” and “noise.”

- (14) a. By the way, my car is making a funny noise

With the understanding that the story is meant to be about asking for directions, the off-topic utterances could cause increases in LD that do not reflect typical vocabulary items used in this discourse elicitation task. This is important because Marini et al. (2005) found that older adults produce more utterances not related to the stimuli than younger adults in a picture description task. This research has been collaborated (Gold, Andres, Arbuckle, & Schwartzman, 1988; Gold Andres, Arbuckle, & Zieren, 1993).

Limitations in LD research make it unclear if there are any age-related differences in LD in discourse production. The use of non-robust estimates of LD, the lack of different discourse types within research, and the lack of research into the quality make it difficult to draw any conclusions. Despite these limitations, no researcher has found LD to decline with age suggesting that LD appears to be resistant to age-related changes.

## Macrolinguistic analysis

Macrolinguistic processes focus on the cohesion, coherence, and completeness of discourse. The focus at the macrolinguistic level for this chapter is on coherence. The coherence of a discourse depends on the ease and extent to which the meanings of its components go together to represent information and convey intended meanings (see, Glosser, 1993; Glosser & Deser, 1992). Coherence has been investigated in cognitively healthy adults using a variety of methods and discourse elicitation tasks. In contrast to findings that lexical measures of discourse, such as lexical diversity, do not decline with age, investigations of discourse coherence show a fairly consistent decline with aging. Declines in coherence in all likelihood represent simultaneous declines in non-linguistic cognitive systems, such as memory, that play a more important role in macrolinguistic processes compared to microlinguistic processes.

In the next section, coherence is fully defined, and several common measures of estimating coherence (e.g. rating systems, error analysis, and main concept production) are discussed. The research on coherence and aging is summarized, with particular attention to the role discourse types have in the age-related changes in coherence. Finally, age-related decline in coherence is discussed in relation to age-related cognitive decline.

## Coherence

Coherence refers to how discourse is connected and organized beyond the level of an utterance (Glosser, 1993; Ulatowska & Olness, 2004), and it is an important aspect for effective communication. Coherent discourse allows the listener the ability to maintain mental representations and understand how these representations are connected within the overall discourse. Researchers have conceptualized levels of discourse coherence: local and global (Glosser & Deser, 1992; Kintsch & van Dijk, 1978). Local coherence considers how well units of discourse (e.g. utterances or propositions) relate to the preceding unit by continuing, repeating, elaborating, or coordinating with the previous unit's overall theme (Glosser & Deser, 1992). Global coherence is how well the units relate to the overall topic or theme of the discourse (Glosser & Deser, 1992; Glosser, 1993; Kintsch & van Dijk, 1978).

### Measures of coherence

Within the literature, researchers have developed several methods for measuring local and global coherence. According to the interactive model of discourse, the purpose of these coherence measures is to capture how well the speaker has maintained the discourse's overall gist or theme locally (i.e. between two utterances) or globally (between an utterance and the overall theme). These measures have included rating systems (Glosser & Deser, 1992; Wright, Koutsoftas, Capilouto, & Fergadiotis, 2014), error analysis (Marini et al., 2005; Saling et al., 2012), main concept counts (Capilouto, Wright, & Wagovich, 2005; Duong & Ska, 2001; North et al., 1986; Saling et al., 2012; Wright, Capilouto, Wagovich, Cranfill, & Davis, 2005), and schema counts (Saling et al., 2012).

**Rating systems** used by Glosser and Deser (1992) and Wright et al. (2014) typically have raters assign a score (e.g. 4-point Likert score) to utterances. Low scores reflect less coherent discourse, and high scores reflect coherent discourse. These ratings are used to measure both local (Glosser & Deser, 1992) and global coherence (Glosser & Deser, 1992; Wright et al., 2014). For local coherence, the raters judge whether an utterance is coherent with the previous utterances. For global coherence, the raters judge whether an utterance is coherent with the overall theme of the discourse. Once all utterances are rated, the scores are summed together and divided by the number of utterances. These results presumably provide researchers with a score that reflects how well a speaker maintained the topic and, in turn, reflect how easily a listener could follow the discourse. Table 2 provides criteria for a 4-point rating system, and Table 3 provides an example based

**Table 2.** Scoring criteria for 4-point coherence rating scale

Score	Criteria
4	Utterance is overtly related to stimulus with all main elements accounted for
3	Utterance is related but may include additional information or may be missing some of the main elements
2	Utterance is remotely related to stimulus with additional information (e.g. tangential information)
1	Utterance is entirely unrelated to the stimulus

Note: Adapted from the scoring system used by Wright et al. (2014).

**Table 3.** Example of coherence for a 4-point rating system

Score	Utterances	Reason for score
4	A little boy is having a birthday party.	Utterance is overtly related to stimulus
4	Um and the mother bakes a cake for the party	Utterance is overtly related to stimulus
2	She is probably tired from cooking	Utterance is remotely related to stimulus with additional information
4	The dog takes a bite out of the cake	Utterance is overtly related to stimulus
1	I once had a dog eat my sandwich	Utterance is not related to stimulus
3	There is crying involved.	Utterance is related but may be missing some of the main elements (i.e. who is crying)
3	Average Rating	

**Table 4.** Examples of Marini's et al. (2005) coherence error analysis

Sample utterances	Global coherence errors
It is a picnic <i>/I like picnics /I have had several picnics in my life/</i>	The second and third utterances are scored as tangential because they provide irrelevant information triggered by a specific idea portrayed in the stimulus picture.
The children are trying to get the cookies <i>/the TV is out/</i>	The second utterance is conceptually incongruent because there is no TV in the picture stimulus
The man is walking on the sidewalk <i>/he is on the sidewalk/</i>	The second utterance is a propositional repetition because the participant repeats ideas that have been mentioned already, and the participant does not provide any additional information.
They are having a picnic <i>/wow I can't believe they haven't noticed</i>	The second utterance is a filler utterance because it simply comments on the story and provides the speaker with time to formulate what to say next

**Table 5.** Example of Wright's et al. (2005) main concept analysis

Utterances	Main event	Score
It's a boy birthday.	It is a boy's Birthday	1
	The boy is crying	0
The dog ate the cake.	Dog ate the boy's cake	1
So the mother is angry,	Mother is angry	1
And the dog is hiding	The dog is under the sofa	1
	Guest are arriving	0
	Total	4/6

on Nicholas and Brookshire's (1993) single picture description, Birthday cake. For the main themes associated with Birthday cake, see Table 5.

**Error analyses** used by Marini et al. (2005) and Saling et al. (2012) measure the number of errors produced within a discourse sample. Utterances that may be tangential or conceptually incongruent with the discourse, propositional repetitions, or simple fillers are considered coherence errors (see Table 4 for examples). Coherence errors disrupt coherence. According to Kintsch and van Dijk (1978), individuals search for conceptual overlap with the last utterance and the overall discourse theme. If no overlap is found, a cognitively demanding search of the entire discourse sample is then initiated. If no conceptual overlap is present, an inference process is initiated. The inference process tries to fit the new utterance into the overall theme of the discourse by searching for possible connections within the listener's knowledge of the world. Therefore, when coherence errors occur, the listener begins a process that makes heavy demands of cognitive resources and contributes to difficulty in comprehension. While high coherence errors do not necessarily reflect low coherence (Marini et al., 2005), error analyses used by Marini et al. (2005) and Saling et al. (2012) provide insight what may be causing the disruption in coherence. Table 4 provides an example of global coherence errors that are typically coded for.

**Main concepts** and **schema** are used less often as methods for quantifying coherence; possibly, because main concepts are unique to the discourse elicitation task and schemas are unique to the discourse type. Further, these methods can be labor and time intensive as they have traditionally been completed by hand. Researchers have developed the main concepts/schema for the discourse task employed in their studies (Capilouto et al., 2005; Duong & Ska, 2001; Saling et al., 2012; Wright et al., 2005; Wright et al., 2014). The main concepts are defined as important aspects of the discourse that are necessary for a listener to fully comprehend it. When applying a schema driven theoretical framework (Herman, 2003; Mandler, 1984) and interactive-construction model (Kintsch & van Dijk,

1978), discourse is considered a series of hierarchically structured and temporally/spatially related events that allows the speaker to coherently produce a discourse that the listener understands. Using the main concepts/schema method to quantify discourse coherence allows investigators to evaluate aspects of the discourse structure that contribute to or inhibit maintenance of global coherence. When the main concepts are not coherently conveyed, then the listener is unable to reconstruct a mental representation of the discourse resulting in discourse that is considered incoherent. Table 5 provides an example of main concept analysis for a single picture, Birthday cake, used by Nicholas and Brookshire (1993).

### Coherence and aging

A number of studies show that the ability to produce coherent discourse declines during healthy aging. Wright et al. (2014) found age-related declines in discourse schema by measuring proportion of story propositions conveyed in story narratives. Duong and Ska (2001) reported that their oldest old (75–84) conveyed fewer main ideas in picture description narratives compared to their young elderly group (65–74). Marini et al. (2005) reported significantly fewer main themes in picture description narratives in their old elderly group compared to other age groups. Wright and Capilouto (2009) reported a sharp decline on measures of coherence ability in older adults (> 75 y.o.) compared to younger adults. Declines in coherence are also consistent across most discourse types: picture descriptions; storytelling; recounts; and procedural discourse.

Glosser and Deser (1992) used a rating system to measure local and global coherence of 14 middle aged ( $M = 51.9$ ) and 13 older adults ( $M = 76.2$ ), who were matched for gender, education, and occupational rating. The researchers elicited personal narratives about the participants' family and occupational activities (i.e. recounts). Each utterance was scored based on how well the utterance maintained content from the preceding utterances (local coherence) and overall theme of the story (global coherence). The older group had significantly lower rates of global coherence compared to middle aged adults; but the groups did not differ on the local coherence measure. The researchers concluded that the differences found between local and global coherence are, in part, due to dissociation in the cognitive systems underlying local and global coherence. Local coherence requires lexical/semantic cohesion between the utterances, and therefore, relies more heavily on the linguistic system than global coherence (Glosser & Deser, 1990). Global coherence relies on other cognitive systems (e.g. memory and attention) outside the linguistic system. In aging, the linguistic system is relatively preserved compared

to memory and attention (Burke & MacKay, 1997), so declines in global coherence are expected.

Marini et al. (2005) investigated local and global coherence in 69 cognitively healthy adults across the adult lifespan. They were divided into five age groups (20–24, 25–39, 40–59, 60–74, 75–84). Marini et al. included several measures to quantify coherence abilities in their participants; these measures include local and global coherence errors, as well as measures of local and global coherence. Local coherence errors included missing or ambiguous referents and semantic shifts. Global coherence errors included off-topic utterances, such as tangential utterances or conceptually unrelated utterances. Estimates of local coherence were determined by dividing the number of cohesive ties in the sample with the number of utterances. Estimates of global coherence were determined by dividing the number of propositions produced by the total number of propositions possible. The discourse elicitation tasks included single-picture and sequential picture stimuli. Marini et al. found that local coherence declined significantly for the oldest group (75–84) compared to the other four groups. Local coherence errors increased with age as well. Global coherence also declined with age beginning around 60 years old. These results were found for both single and sequential picture tasks, with single pictures eliciting less coherent discourse compared to the sequential pictures.

Marini et al. (2005) concluded that local and global coherence may depend on similar cognitive abilities because both declined with age. Yet, similar to Glosser and Deser (1992), Marini et al. (2005) found that local coherence is more resistant to age related changes compared with global coherence. Local coherence did not significantly decline until around 75 years old compared with 60 years old for global coherence. Therefore, local and global coherence may rely on overlapping but different cognitive systems. Alternatively, it is possible that a direct comparison is not possible since Glosser and Deser's (1992) participants range from 67 to 88 years old compared to Marini et al.'s (2005) range of 75 to 84 years old.

Another difference between Marini et al. (2005) and Glosser and Deser (1992) is discourse type. Marini et al. used single and sequential picture description task, while Glosser and Deser used recounts. Recounts rely on personal information stored in long-term memory that is familiar to the participant. Glosser and Deser (1992) claimed that the disruption of local coherence in picture description tasks may arise from the need to retain new semantic information and build connections between this new information. Ulatowska, Hayashi, Cannito, and Flemings (1986) and Pratt et al. (1989) results illustrate this point. These researchers found significant cohesion deficits for storytelling tasks that would be indicative of reduced local coherence.

North et al. (1986) investigated global coherence in 33 older women, with a mean age of 76.2 years, and 18 middle-aged women, with a mean age of 45.6 years. Estimates of global coherence were measured by creating a list of propositions for each discourse type and counting the number of propositions produced for the two age groups. The stimuli consisted of picture descriptions, storytelling, recounts, and procedural discourse. Unfortunately, the open nature of the recounts made it difficult to score propositions, and the results for the recounts were not reported. The researchers found that the groups did not differ in the number of propositions produced for the procedural discourse task. North et al. concluded that procedural discourse tasks require participants to recall a step-by-step guide that is highly regularized and familiar. Therefore, unlike the picture description task in Marini et al. (2005), procedural discourse is resistant to the age-related changes that affect global coherence.

Duong and Ska (2001) also examined local and global coherence in older adults between the ages of 64 to 74 and 75 to 84 years. The researchers estimated local coherence by counting the number of transition markers. Global coherence was estimated as a percentage of main ideas expressed within the discourse samples. The discourse stimuli included both single and sequential pictures. Adults between the ages of 64 to 74 produced more main concepts and used more transitional words in their discourse samples compared to the oldest old (75–84 years). Therefore, much like Marini et al. (2005), Duong and Ska found that coherence declines as a person ages. Also similar to Marini et al., they found that all participants performed better on the sequential picture task than single picture task. The differences found between single pictures and sequential pictures by Marini et al. (2005) and Duong and Ska (2001) may reflect the temporal and, therefore, plot progression of the sequential pictures compared with the single pictures.

Capilouto et al. (2005) investigated global coherence in younger ( $M$  age = 22.4) and older ( $M$  age = 71.4) adults. To measure global coherence, the researchers developed a list of main events, which they defined as events necessary to the story that are independent from other events, for single and sequential pictures taken from Nicholas and Brookshire (1993). The researchers found no difference between the younger and older adults for proportion of main events produced. Yet between discourse types, participants produced more main events for sequential pictures compared to single pictures.

Capilouto et al. (2005) concluded that while other researchers found differences in coherence between younger and older adults, the global coherence measures used in their study (i.e. main events) examined only the most critical elements of a story. When only the critical aspects of a story are examined, older adults do not perform worse than younger adults. While older adults may have trouble on more fine-grain measures of coherence, they are able to tell stories with the most

important information present. For discourse type, Capilouto et al.'s (2005) results agreed with Marini et al. (2005) and Duong and Ska (2001).

Wright et al. (2005) examined global coherence in both younger ( $M = 23.9$  years old) and older (67.6 years old) adults. Similar to Capilouto et al. (2005), main event analysis was used to measure global coherence. The researchers used both single and sequential pictures as discourse stimuli. Wright et al. found a significant difference between the younger and older adults, with the younger adults producing more main concepts compared to older adults. The results agree with other researchers who have found that older adults produce fewer story schemata (Saling et al., 2012). For discourse type, Wright et al. found better performance on sequential pictures than single pictures. They concluded that the single picture descriptions provide older adults with another level of difficulty because it requires participants to make inference about the sequence of events. Moreover, they concluded that picture descriptions may reflect the true nature of discourse abilities in older adults because the older adults cannot fall back on rehearsed and regularized stories unlike recount and procedural task.

There is strong evidence that local and global coherence decline with age, along with an increase in coherence errors (Capilouto et al., 2005; Duong & Ska, 2001; Glosser & Deser, 1992; Marini et al., 2005; North et al., 1986; Wright et al., 2005). Local coherence may be more resistant to age-related declines (Glosser & Deser, 1992; Marini et al., 2005) compared to global coherence. This may be due to the fact that local coherence requires, in part, some linguistic processes that are more resistant to age-related decline (Glosser & Deser, 1992). However, the results from Marini et al. (2005) demonstrate that local and global coherence are subserved by overlapping cognitive systems since both decline with age.

Coherence appears to be strongly tied to discourse type (Capilouto et al., 2005; Duong & Ska, 2001; Glosser & Deser, 1992; Marini et al., 2005; North et al., 1986; Wright et al., 2005). Recounts and procedural discourse are the most resistant to age related declines (Glosser & Deser, 1992; North et al., 1986). North et al. (1986) and Wright et al. (2005) argued that recounts and procedural discourse are typically familiar and highly regularized, so participants can better compensate for any age related declines in organizational discourse abilities. Picture description tasks might be a better reflection of true discourse abilities (Wright et al., 2005). Glosser and Desser (1992) claimed that picture description tasks require participants to store new information and build connections between this new information. This takes more cognitive resources (e.g. memory storage) than relating already familiar concepts. Therefore, as shown in table 8.6 older adults, who have declining storage capacity, have more trouble on picture descriptions compared with recounts or procedures.

**Table 6.** Discourse type and coherence in older adults

Discourse type	Local coherence	Global coherence
Recounts	No decline	Small declines
Procedural	No decline	No decline
Eventcast	Large declines	Large declines
Storytelling	Large declines	Large declines

## Coherence and aging: Cognition

Kintsch and van Dijk's (1978) Interactive-Construction model of discourse implicates attention, episodic memory, and working memory as the most important cognitive system for coherence. Attention is the ability to focus on important information while inhibiting useless or distracting information, and it has a limited capacity. Episodic memory refers to our ability to remember specific events or episodes (Light, 1991; Nyberg, Backman, Erngrund, Olofsson, & Nilsson, 1996; Small, Stern, Tang, & Mayeux, 1999), and working memory is an active memory system that stores information and integrates/processes this information with new incoming information (Baddeley, 1996). As an individual ages, attention (McDowd & Shaw, 2000) and memory (Light, 1991; Marini et al., 2005; Nyberg et al., 1996) decline.

North et al. (1986) reported declines in both cognitive scores and coherence; however, the scores were not significantly correlated. Capilouto et al. (2011) and Wright et al. (2013) reported that memory and attention abilities significantly correlated with global coherence for the older group but not the younger group. Finally, in an unpublished study by Fergadiotis, Kintz and Wright, a linear regression was performed to understand the relationship among cognitive measures and global coherence in a sample of the older adults ( $N = 103$ ; ages 65–89 years). Results indicated that cognitive predictors (episodic memory, working memory, and attention) explained 12.9% of the variance in global coherence. The results from these studies suggest that declines in cognition affect older adults' coherence in discourse. Yet cognitive scores for younger adults are not correlated with and do not significantly explain the variance in global coherence scores.

Wright et al. (2014) examined the influence of cognitive processes on discourse coherence for both younger adults between the ages of 20–39 and older adults between the ages of 70–87. Measures of cognition included the Wechsler Memory Scale-III (WMS-III; Wechsler, 1997), Comprehensive Trail Making Test (CTMT; Reynolds, 2002); and STROOP Color and Word Test (STROOP; Golden, 2002). Coherence measures included a 4-point rating scale on several discourse stimuli: picture descriptions, storytelling, recounts, and procedures. Wright et al.

(2013) found a positive relationship for the maintenance of global coherence and attention and episodic memory.

The researchers concluded that attention and episodic memory are important for maintaining global coherence as individuals' age. Burke and MacKay (1997) hypothesized that episodic memory's ability to form new memories and make new connections declines with age. Therefore, declines in episodic memory result in declines in coherence maintenance. Hasher, Lustig, and Zacks (2007) have proposed the inhibition-deficit theory to account for age-related declines in attention. The idea is that a deficit in inhibiting irrelevant information takes up older adults' cognitive resources that should be handling discourse, so there are fewer resources available for processing discourse and maintain focus on the discourse themes.

Though researchers assume that declines in coherence with age are related to declines in cognitive systems outside the linguistic system, there are only a few studies that have empirically investigated cognition and coherence across the lifespan. There are even fewer studies examining cognition and coherence across the lifespan within a discourse model (e.g. interactive-construction model). These limitations prevent researchers from fully specifying the exact cognitive processes that underlie coherence.

## Future directions

The influence of age on discourse processes is not fully understood and an area where further research and investigations are warranted. Overall, researchers need to: (1) identify differences in micro- and macrolinguistic processes across the adult lifespan, (2) identify differences in comprehension and production across the adult lifespan, and (3) identify specific cognitive functions that influence these changes. It is also important to relate these changes to known models of discourse. Currently, few researchers are putting their results within the framework of known discourse models. Instead, many researchers are focusing on simply documenting the changes seen between younger and older adults. Future research will need to be model-driven and hypothesis guided.

For lexical diversity, research needs to rely less on measures with known limitations in regards to sample length (e.g. TTR or NDW) and focus on robust lexical diversity measures (e.g. D and MTLTD). While lexical diversity appears resistant to age-related changes, the research is not conclusive. The inconclusiveness is associated with the unreliable measures that have been used in the past (Cooper, 1990). To test lexical diversity reliably, D or MTLTD need to be used across the adult lifespan for different types of discourse. Other variables, like education,

cognitive scores (i.e. semantic memory, verbal fluency, etc.), and participants' goal and communication style should also be taken into account. Also, to understand the reasons behind differences in lexical diversity associated with discourse type, the differences and cognitive demands of different discourse types should be quantified.

Coherence declines with age (Capilouto et al., 2005; Duong & Ska, 2001; Glosser & Deser, 1992; Marini et al., 2005; North et al., 1986; Saling et al., 2012; Wright et al., 2005; Wright et al., 2014), but most statements regarding why make generic cognitive statements without specific cognitive measures being taken. Future research will need to begin quantifying the actual roles each cognitive system plays in maintaining coherence. Researchers will also need to quantify the different cognitive and linguistic demands placed upon the speaker and listener for different discourse types.

## Conclusions

Discourse has many aspects that are differentially affected by age-related changes. Microlinguistic processes, such as lexical diversity, appear to be resistant to age-related decline. In contrast, macrolinguistic processes, such as coherence, are more susceptible to age-related decline. The general conclusion is that lexical diversity and coherence tap different neuro-cognitive processes that differentially change as individual's age. Alternatively, discourse type influences both lexical diversity and coherence differently with age. For lexical diversity, open discourse tasks (e.g. recounts) offer more opportunities to use a wider range of lexical items that increases lexical diversity for older adults. Yet many open discourse tasks are familiar and allow for older individuals to use compensation strategies in organizing their discourse, which makes these tasks less useful in measuring coherence in older adults.

To advance theoretical and practical understand of age-related changes in discourse abilities, research is needed regarding the influence age has on discourse type and different linguistic processes. Such evidence is also needed to assess the importance of different age-related changes in cognition in regards to discourse. Research into normal aging declines for discourse will provide us with a knowledge base to better understand language deficits in language-disordered populations, such as aphasia and dementia. The challenge to this research arises from the integration of discourse models and cognitive aging, and in analyzing discourse in a manner that reveals age-related changes and how those changes depends on age-related changes in cognition.

## References

- Albert, M. S., Heller, H. S., & Milberg, W. (1988). Changes in naming ability with age. *Psychology and Aging*, 3, 173–178. doi:10.1037/0882-7974.3.2.173
- Albert, M. L., Spiro, A., Sayers, K. J., Cohen, J. A., Brady, C. B., Goral, M., & Obler, L. K. (2009). Effects of health status on word finding in aging. *Journal of the American Geriatrics Society*, 57, 2300–2305. doi:10.1111/j.1532-5415.2009.02559.x
- Arbuckle, T. Y. & Gold, D. P. (1993). Aging, inhibition, and verbosity. *Journal of Gerontology: Psychological Sciences*, 48, P225–P232. doi:10.1093/geronj/48.5.P225
- Baddeley, A. D. (1996). Exploring the central executive. *The Quarterly Journal of Experimental Psychology*, 49, 5–28. doi:10.1080/713755608
- Brownell, H. H. (1988). The neuropsychology of narrative comprehension. *Aphasiology*, 2, 247–250. doi:10.1080/02687038808248918
- Burke, D. M., & MacKay, D. G. (1997). Memory, language, and ageing. *Philosophical Transactions of the Royal Society of London - Series B: Biological Sciences*, 352, 1845–1856. doi:10.1098/rstb.1997.0170
- Capilouto, G. J., Wright, H. H., & Wagovich, S. A. (2005). CIU and main event analyses of the structured discourse of older and younger adults. *Journal of Communication Disorders*, 38, 431–444. doi:10.1016/j.jcomdis.2005.03.005
- Chappelle, C. A. (1994). Are C-tests valid measures for L2 vocabulary research? *Second Language Research*, 10(2), 157–187. doi:10.1177/026765839401000203
- Chomsky, N. (1980). *Rules and representations*. New York, NY: Columbia University Press.
- Chotlos, J. W. (1944). Studies in language behavior. IV. A statistical and comparative analysis of individual written language samples. *Psychological Monographs*, 56, 75–111.
- Christiansen, J. A. (1995). Coherence violations and propositional usage in the narratives of fluent aphasics. *Brain and Language*, 51, 291–317. doi:10.1006/brln.1995.1062
- Connor, L. T., Spiro, A., Obler, L. K., & Albert, M. L. (2004). Change in object naming ability during adulthood. *The Journals of Gerontology: Series B*, 59(5), 203–209. doi:10.1093/geronb/59.5.P203
- Cooper, P. V. (1990). Discourse production and normal aging: Performance on oral picture description tasks. *Journal of Gerontology*, 45(5), 210–214. doi:10.1093/geronj/45.5.P210
- Duong, A., & Ska, B. (2001). Production of narratives: Picture sequence facilitates organizational but not conceptual processing in less educated subjects. *Brain and Language*, 45(121), 124.
- Durán, P., Malvern, D., Richards, B., & Chipere, N. (2004). Developmental trends in lexical diversity. *Applied Linguistics*, 25(2), 220–242. doi:10.1093/applin/25.2.220
- Fergadiotis, G. (2011). *Modeling lexical diversity across language samples and estimation techniques*. PhD, Arizona State University. ProQuest LLC, 198. (3486935).
- Fergadiotis, G., & Wright, H. H. (2011). Lexical diversity for adults with and without aphasia across discourse elicitation tasks. *Aphasiology*, 25(11), 1414–1430. doi:10.1080/02687038.2011.603898
- Fergadiotis, G., Wright, H. H., & Capilouto, G. J. (2011). Productive vocabulary across discourse types. *Aphasiology*, 25(10), 1261–1278. doi:10.1080/02687038.2011.606974
- Fergadiotis, G., Wright, H. H., & West, T. M. (2013). Measuring lexical diversity in narrative discourse of people with aphasia. *American Journal of Speech-Language Pathology*, 22(2). doi:10.1044/1058-0360(2013)12-0083)

- Glosser, G. (1993). Discourse production patterns in neurologically impaired and aged populations. In H. H. Brownell, & Y. Joanette (Eds.), *Narrative discourse in neurologically impaired and normal aging adults* (pp. 191–211). San Diego, CA: Singular.
- Glosser, G., & Deser, T. (1990). Patterns of discourse production among neurological patients with fluent language disorders. *Brain and Language*, 40, 67–88.  
doi:10.1016/0093-934X(91)90117-J
- Glosser, G., & Deser, T. (1992). A comparison of changes in macrolinguistic and microlinguistic aspects of discourse production in normal aging. *Journal of Gerontology*, 47, 266–272.  
doi:10.1093/geronj/47.4.P266
- Gold, D. P., Andres, D., Arbuckle, T., & Schwartzman, A. (1988). Measurement and correlates of verbosity in elderly people. *Journal of Gerontology: Psychological Sciences*, 43, P27–P34.
- Gold, D. P., Andres, D., Arbuckle, T., & Zieren, C. (1993). Off-topic verbosity and talkativeness in elderly people. *Canadian Journal on Aging*, 12, 67–77. doi:10.1017/S0714980800008278
- Golden, C. (2002). *Stroop color and word test*. Austin, TX: Pro-Ed.
- Goodglass, H., & Kaplan, E. (1976). *The assessment of aphasia and related disorders*. Philadelphia, PA: Lea & Febiger.
- Griffin, Z. M., & Spieler, D. H. (2006). Observing the what and when of language production for different age groups by monitoring speakers' eye movements. *Brain and language*, 99(3), 272–288. doi:10.1016/j.bandl.2005.08.003
- Guiraud, P. (1960). *Problèmes et méthodes de la statistique linguistique*. Dordrecht: Reidel.
- Hasher, L., Lustig, C., & Zacks, R. (2007). Inhibitory mechanisms and the control of attention. In A. R. Conway, C. Jarrold, M. J. Kane, A. Miyake & J. N. Towse (Eds.), *Variation in working memory* (pp. 227–249). Oxford: Oxford University Press.
- Hasher, L., & Zacks, R. T. (1988). Working memory, comprehension, and aging: A review and a new view. *Psychology of Learning and Motivation*, 22, 193–225.  
doi:10.1016/S0079-7421(08)60041-9
- Heap, H. S. (1978). *Information retrieval - computational and theoretical aspects*. New York, NY: Academic Press.
- Herman, D. (2003). Stories as tool for thinking. In D. Herman (Ed.), *Narrative theory and the cognitive sciences* (pp. 163–192). Stanford, CA: CSLI.
- Howard, D., & Patterson, K. (1992). *Pyramids and palm trees: A test of semantic access from pictures and words*. London: Thames Valley.
- Jarvis, S. (2002). Short texts, best-fitting curves and new measures of lexical diversity. *Language Testing*, 19(1), 57–84. doi:10.1191/0265532202lt2200a
- Kaplan, E., Goodglass, H., & Weintraub, S. (2001). *Boston naming test* (2nd ed.). Austin, TX: Pro-Ed.
- Kemper, S., Marquis, J., & Thompson, M. (2001). Longitudinal change in language production: Effects of aging and dementia on grammatical complexity and propositional content. *Psychology and Aging*, 16, 600–614. doi:10.1037/0882-7974.16.4.600
- Kemper, S., Schmalzried, R., Hoffman, L., & Herman, R. (2010). Aging and the vulnerability of speech to dual task demands. *Psychology and Aging*, 25(4), 949–962. doi:10.1037/a0020000
- Kemper, S., & Sumner, A. (2001). The structure of verbal abilities in young and old adults. *Psychology and Aging*, 16(2), 312–322. doi:10.1037/0882-7974.16.2.312
- Kintsch, W. (1994). The psychology of discourse processing. In M. A. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 721–739). San Diego, CA: Academic Press, Inc.
- Kintsch, W. (1998). The use of knowledge in discourse processing: A construction-integration mode. *Psychological Review*, 95, 163–182. doi:10.1037/0033-295X.95.2.163

- Kintsch, W., & van Dijk, T. A. (1978). Toward a model of text comprehension and production. *Psychological Review*, 85(5), 363–394. doi:10.1037/0033-295X.85.5.363
- Koizumi, R., & In'nami, Y. (2012). Effects of text length on lexical diversity measures: Using short texts with less than 200 tokens. *System*, 40, 554–564. doi:10.1016/j.system.2012.10.012
- LaBarge, E., Edwards, D., & Knesevich, J. W. (1986). Performance of normal elderly on the Boston naming test. *Brain and Language*, 27(2), 380–384. doi:10.1016/0093-934X(86)90026-X
- Light, L. L. (1991). Memory and aging: Four hypotheses in search of data. *Annual Review of Psychology*, 42, 333–376. doi:10.1146/annurev.ps.42.020191.002001
- Maas, H. D. (1972). Zusammenhang zwischen wortschatzumfang und länge eines textes. *Zeitschrift Für Literaturwissenschaft Und Linguistik*, 8, 73–79.
- Malvern, D. D., & Richards, B. J. (1997). A new measure of lexical diversity. In A. Ryan, & A. Wray (Eds.), *Evolving models of language* (pp. 58–71). Clevedon: Multilingual Matters.
- Mandler, J. M. (1984). *Stories, scripts, and scenes: Aspects of schema theory*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Marini, A., Boewe, A., Caltagirone, C., & Carlomagno, S. (2005). Age-related differences in the production of textual descriptions. *Journal of Psycholinguistic Research*, 34(5), 439–463. doi:10.1007/s10936-005-6203-z
- McCarthy, P. M. (2005). An assessment of the range and usefulness of lexical diversity measures and the potential of the measure of textual lexical diversity. Doctoral dissertation. ProQuest Nursing & Allied Health Source Database.
- McCully, E. A. (1984). *Picnic*. New York, NY: Harper Collins.
- McDowd, J. M., & Shaw, R. J. (2000). Attention and aging: A functional perspective. In F. I. M. Craik, & T. A. Salthouse (Eds.), *The handbook of aging and cognition* (2nd ed.; pp. 221–292). Mahwah, NJ: Lawrence Erlbaum Associates.
- McKee, G., Malvern, D., & Richards, B. (2000). Measuring vocabulary diversity using dedicated software. *Literary and Linguistic Computing*, 15(3), 323–337. doi:10.1093/lc/15.3.323
- McNeil, M. R., & Pratt, S. R. (2001). Defining aphasia: Some theoretical and clinical implication of operating from a from definition. *Aphasiology*, 15(10), 901–911. doi:10.1080/02687040143000276
- Nicholas, L. E., & Brookshire, R. H. (1993). A system for quantifying the informativeness and efficiency of the connected speech of adults with aphasia. *Journal of Speech and Hearing Research*, 36(2), 338–350. doi:10.1044/jshr.3602.338
- North, A., J., Ulatowska, H. K., Macaluso-Haynes, S., & Bell, H. (1986). Discourse performance in older adults. *International Journal of Aging and Human Development*, 23(4), 267–283. doi:10.2190/BPFo-2BWD-BGNQ-HWCW
- Nyberg, L., Backman, L., Erngrund, K., Olofsson, U., & Nilsson, L. (1996). Age differences in episodic memory, semantic memory, and priming: Relationships to demographics, intellectual, and biological factors. *Journal of Gerontology*, 51B, 234–240. doi:10.1093/geronb/51B.4.P234
- Pratt, M. W., Boyes, C., Robins, S., & Manchester, J. (1989). Telling tales: Aging, working memory, and the narrative cohesion of story retelling. *Developmental Psychology*, 25, 628–635. doi:10.1037/0012-1649.25.4.628
- Reynolds, C. R. (2002). *Comprehensive trail making test*. Austin, TX: Pro-Ed.
- Saling, L., L., Laroo, N., & Saling, M., M. (2012). When more is less: Failure to compress discourse with re-telling in normal aging. *Acta Psychologica*, 139, 220–224. doi:10.1016/j.actpsy.2011.10.005

- Salthouse, T., & Babcock, R. L. (1991). Decomposing adult age differences in working memory. *Developmental Psychology, 27*, 763–776. doi:10.1037/0012-1649.27.5.763
- Schaie, K. W., & Willis, S. L. (1993). Age difference patterns of psychometric intelligence in adulthood: Generalizability within and across ability domains. *Psychology and Aging, 8*, 44–55. doi:10.1037/0882-7974.8.1.44
- Shadden, B. B. (1997). Discourse behaviors in older adults. *Seminars in Speech and Language, 18*, 413–157. doi:10.1055/s-2008-1064069
- Shelley-Tremblay, J. (2011). Theories of semantic processing. In J. Guendouzi, F. Loncke & M. J. Williams (Eds.), *The handbook of psycholinguistic and cognitive processes* (pp. 209–226). New York, NY: Psychology Press.
- Small, S. A., Stern, Y., Tang, M., & Mayeux, R. (1999). Selective decline in memory function among healthy elderly. *Neurology, 52*, 1392–1996. doi:10.1212/WNL.52.7.1392
- Stemmer, B. (1999). Discourse studies in neurologically impaired populations: A quest for action. *Brain and Language, 68*, 402–418. doi:10.1006/brln.1999.2120
- Templin, M. (1957). *Certain language skills in children*. Minneapolis, MN: University of Minneapolis Press.
- Tweedie, F. J., & Baayen, R. H. (1998). How variable may a constant be? measures of lexical richness in perspective. *Computers and the Humanities, 32*(5), 323–352. doi:10.1023/A:1001749303137
- Ulatowska, H. K., Hayashi, M. M., Cannito, M. P., & Fleming, S. G. (1986). Disruption of reference in aging. *Brain and Language, 28*, 24–41. doi:10.1016/0093-934X(86)90088-X
- Ulatowska, H. K., & Olness, G. S. (2004). Discourse. In R. D. Kent (Ed.), *The MIT encyclopedia of communication disorders* (pp. 300–302). Cambridge, MA: The MIT Press.
- van Dijk, T. A. (Ed.). (1997). *Discourse as structure and process*. Thousand Oaks, CA: Sage.
- Wechsler, D. (1981). *WAIS-R manual: Wechsler adult intelligence scale-revised*. San Antonio, TX: Psychological Corporation.
- Wechsler, D. (1997). *Wechsler memory scale* (3rd ed.). San Antonio, TX: Psychological Corporation.
- Wright, H. H., & Capilouto, G. J. (2009). Manipulating task instruction to change narrative discourse performance. *Aphasiology, 23*, 1295–1308. doi:10.1080/02687030902826844
- Wright, H. H., & Capilouto, G. J. (2012). Considering a multi-level approach to understanding maintenance of global coherence in adults with aphasia. *Aphasiology, 26*(5), 656–672. doi:10.1080/02687038.2012.676855
- Wright, H. H., Capilouto, G. J., Koutsoftas, A. (2013). Evaluating measures of global coherence ability in stories in adults. *International Journal of Language and Communication Disorders, 48*(3), 249–265. doi:10.1111/1460-6984.12000
- Wright, H. H., Capilouto, G. J., Wagovich, S. A., Cranfill, T. B., & Davis, J. E. (2005). Development and reliability of a quantitative measure of adults' narratives. *Aphasiology, 19*(3/4/5), 263–273. doi:10.1080/02687030444000732
- Wright, H. H., Koutsoftas, A. D., Capilouto, G. J., & Fergadiotis, G. (2014). Global coherence in younger and older adults: Influence of cognitive processes and discourse type. *Aging, Neuropsychology, and Cognition, 21*(2), 174–196. doi:10.1080/13825585.2013.794894
- Yu, G. (2009). Lexical diversity in writing and speaking task performances. *Applied Linguistics, 3*(1/2), 236–259.

## Language comprehension in aging

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There is a lot of evidence that sentence comprehension ability declines in normally aging adults. This chapter reviews variables that contribute to age-related declines in comprehension. Older adults recognize words and parse sentences more slowly than younger adults, and make more comprehension errors. These changes in comprehension ability have been associated with age-related declines in general cognitive processes, such as working memory, and in perceptual abilities, such as hearing acuity. This chapter also considers the possibility that older adults use their language expertise to compensate for age-related declines in comprehension ability.

### Processes involved in sentence comprehension

Most people take the ability to understand sentences quickly and accurately for granted. However, the underlying processes are not simple. Sentence comprehension requires that the reader or listener recognize the words in a sentence, build a mental representation of the relationship between the words, and assign meaning to the sentence. There is a lot of evidence that people process sentences incrementally, meaning that they interpret and integrate the words in the sentence as they are encountered. This process is also known as syntactic parsing. Syntactic parsing operations involve determining who did what to whom in the context of the sentence. Consider a sentence such as “*The boy kicked the ball.*” In this sentence, “*the boy*” is the agent of the verb, that is, the kicker. In contrast, “*the ball*” is the undergoer, that is, the object that was kicked. In most English sentences, the subject of the sentence is also the agent of the verb. This sentence follows the canonical word order for English, which is Subject-Verb-Object (SVO). However, the relationship between “*the ball*,” “*the boy*,” and “*kicked*” is the same in a sentence such as “*The ball was kicked by the boy,*” even though the order of words in the sentence differs. The ability to perform the operations involved in understanding sentences can be compromised by brain damage, degenerative diseases, and even

normal aging. This chapter discusses the ways in which sentence comprehension changes in normally aging adults, including how linguistic variables and general cognitive abilities contribute to these changes.

A complete understanding of how sentence comprehension changes in normal aging requires consideration of both online and offline syntactic parsing. Measures of sentence comprehension that are sensitive to the moment-by-moment operations involved in incremental sentence parsing are known as online tasks. Box 1 describes some of the experimental paradigms used to measure online syntactic parsing operations. In contrast, offline measures are taken at the end of the sentence, and reflect the products of online processing. Offline measures include accuracy and speed of responses to comprehension questions, plausibility judgments, enactment tasks, and so on. In general, online tasks are considered to be more sensitive to the variables that influence syntactic parsing. Both online and offline measures have been used to investigate age-related changes in sentence comprehension ability.

In the following sections (II–IV), we review several variables that contribute to comprehension success or failure in older adults. In Section II, we discuss linguistic variables that affect sentence comprehension in older adults. We begin by considering how variables that contribute to the ease of word recognition affect comprehension ability in older adults. These include lexical complexity (e.g., word frequency) and the predictability of words in sentences. Next, we review how word order influences comprehension success in older adults, including how age-related changes in working memory affect sentence comprehension. In Section III, we discuss how age-related changes in visual and auditory acuity affect language comprehension. In Section IV, we review recent studies suggesting that older adults use their language experience to compensate for age-related declines in comprehension ability.

## Sentence-related variables

### Word recognition

Sentence comprehension requires that the reader or listener recognize the words in the sentence. A complete review of the processes involved in spoken and written comprehension of words in sentences is beyond the scope of this chapter. In brief, word recognition requires that the reader or listener first activate the appropriate phonological (sound) or orthographic (written) representations (for reviews, see Balota, Yap, & Cortese, 2006 and Dahan & Magnuson, 2006). This step involves identifying the abstract phonological or orthographic representation that

matches the input, which varies depending on the speaker/writer and the context in which the word is produced. The abstract phonological and orthographic representations activate the semantic/conceptual level information about the word. For example, the semantic information for the word “*cat*” likely includes that it refers to an animal, that it is soft, that it is a type of pet, and so on. According to some models, there is also feedback from the semantic level to the phonological or orthographic level, meaning that the sounds /k/, /æ/, and /t/ receive additional activation from these semantic features.

There is evidence that older adults recognize words in sentences more slowly than younger adults. Two eyetracking studies, both of which focused on factors affecting lexical recognition across a range of sentence types, reported that older adults read individual words more slowly than younger adults do (Kliegl, Grabner, Rolfs, & Engbert, 2004; Rayner, Reichle, Stroud, Williams, & Pollatsek, 2006). This is consistent with studies that have focused on sentence level processing. For example, in a self-paced reading study, Stine-Morrow, Ryan, and Leonard (2000) reported that older adults read individual words or segments more slowly than younger adults throughout the sentence. This type of result is likely to reflect overall slowed processing in older adults (cf. Salthouse, 1996).

In addition to general slowing, older adults show greater sensitivity than younger adults to some variables that increase the difficulty of word recognition. Word frequency is one such variable. Word frequency refers to how common a word is within a language. For example, the word “*child*” occurs more often in English than “*tyke*.” Frequently occurring words are recognized more quickly than less frequent words (e.g., DeDe, 2012; Inhoff & Rayner, 1986). Older adults show greater effects of word frequency than younger adults, in both reading (Kliegl et al., 2004; Rayner et al., 2006) and auditory comprehension (Revill & Spieler, 2012). That is, older adults have more difficulty accessing relatively infrequent words than younger adults.

There is also some evidence that phonological neighborhood density has a greater effect on speech recognition in older than younger adults. Phonological neighborhood density refers to the number of words that differ from a target word by one sound. For example, *can*, *mat*, *gnat*, and *cap* would all be phonological neighbors of the word “*cat*”. In general, spoken words with few phonological neighbors are recognized more quickly and accurately than words with many phonological neighbors (e.g., Luce & Pisoni, 1998). One study used repetition accuracy as an index of older and younger adults’ ability to perceive sentences that varied with respect to the phonological neighborhood density of words (Taler, Aaron, Steinmetz, & Pisoni, 2010). They reasoned that accuracy reflected word recognition, whereas response duration was a measure of how difficult it was to produce the lexical items. Both older and younger adults repeated words with few

phonological neighbors more accurately than words with many neighbors, but older adults showed a greater effect of neighborhood density than younger adults. Interestingly, the effect of neighborhood density on older adults' recognition was greater when the sentences were presented in the presence of background noise. This finding is consistent with the idea that increasing the perceptual difficulty of word recognition has a disproportionate effect on older adults (see Section III), and that this effect interacts with lexical variables.

Successful word recognition also requires that the reader or listener know the meaning of the word. This is an area in which older adults have an advantage over younger adults. In a meta-analysis of studies reported in the journal *Psychology and Aging* between 1986 and 2001, Verhaeghen (2003) reported a consistent, positive age effect on vocabulary scores. Older adults' mean standardized difference scores were between .63 and 1.62 greater than younger adults' scores on the measures of vocabulary. Verhaeghen's analyses suggested that differences in the test format and in educational attainment might mitigate the apparent effect of age. Age effects were more apparent in multiple-choice tests than production tests, in which participants must generate definitions. Regardless, the older adults' increased difficulty understanding sentences is unlikely to reflect declining knowledge of the lexical items in a sentence.

Taken together, the studies about word recognition in normal aging suggest that older adults recognize words more slowly than younger adults. In addition, older adults appear to be more sensitive to variables that make word recognition more difficult, such as lexical frequency and phonological neighborhood density. However, older adults retain lexical knowledge, suggesting that the age related changes reflect access to semantic representations rather than lack of knowledge about the words.

## Predictability

Word recognition is easier when words are presented in the context of a semantically coherent sentence (Speranza, Daneman, & Schneider, 2000). Consider the phrase "*The boy kicked the ....*" In this case, the comprehender is more likely to encounter the word "*ball*" than "*door*," even though both are possible. The semantic context of the sentence allows readers to predict what the last word will be, based on world knowledge and previous experience with their language.

Both younger and older adults recognize isolated words more slowly than words that occur in the context of a sentence (e.g., Pichora-Fuller, Schneider, & Daneman, 1995; Wingfield, Alexander, & Cavigelli, 1994). In addition, highly constrained contexts can increase the predictability of a word in a sentence, facilitating

word recognition. For example, consider the phrase “*Since the wedding was today, the baker rushed the wedding ...*” (Balota, Pollatsek, & Rayner, 1985). In this context, “*cake*” is more predictable as the next word in the sentence than “*pie*.” Use of predictability requires that the reader or listener integrate the semantic context of the sentence in order to generate a prediction of upcoming words in the sentence. There is evidence that people are more likely to skip words that are highly predictable within the context of the sentence, and that they read predictable words more quickly than less predictable words (e.g., Balota et al., 1985; Drieghe, Rayner, & Pollatsek, 2005).

Behavioral studies point to some differences in how older and younger adults use predictability during sentence comprehension. Eyetracking studies show that both older and younger adults are sensitive to the effects of predictability (Kliegl et al., 2004; Rayner et al., 2006). However, Kliegl et al.’s (2004) results suggest that predictability effects differ somewhat in older and younger adults. They found that both older and younger adults were sensitive to predictability, but the nature of the effect differed between the groups. Younger adults tended to skip highly predictable words, but older adults did not show the predictability effect in skipping rates. Instead, older adults made more fixations on unpredictable words and fewer fixations on highly predictable words. Thus, both age groups read highly predictable words more quickly than less predictable words, but the reading advantage for predictable words manifested differently as a function of age.

Predictability of words in a sentence also facilitates comprehension of sentences presented with background noise. In one study, both older and younger adults showed better recognition of sentence-final words of sentences presented in background noise when the sentences were highly semantically constrained (Sheldon, Pichora-Fuller, & Schneider, 2008). This is consistent with the idea that older and younger adults are sensitive to information about predictability. However, the effects of semantic predictability were greater in older than younger adults, suggesting that older adults used the semantic context of a sentence to compensate for perceptual difficulty associated with the stimulus. It is important to note that this study does not provide information into the time course with which older and younger adults use information about predictability, in part because the task (repeating the sentence-final word) was untimed. Thus, it is possible that increased age is associated with a decline in the speed with which semantic information is integrated in order to benefit from predictability.

Indeed, data from a series of event-related potential (ERP; see Box 1) studies suggest that there are differences in how predictability affects word recognition in older and younger adults. Federmeier and her colleagues have examined N400 effects in sentences with strongly and weakly constraining contexts (e.g., Federmeier, Van Petten, Schwartz, & Kutas, 2003; Federmeier & Kutas, 2005;

Box 1. Some online measures of sentence processing

Method	Description	Measurement
<b>Self-paced listening</b> (e.g., Waters & Caplan, 2001, 2005)	Participants listen to sentences presented auditorily via a computer. Sentences are segmented into words or short phrases. Participants press a button to listen to the first segment of the sentence, and then press a button to indicate that they are finished listening to the segment. As soon as they press the button, they are presented with the next segment.	The computer records how long it takes the participant to press the button to request each segment. Longer listening times indicate difficulty with processing or integration of information.
<b>Self-paced reading</b> (e.g., Stine-Morrow, Ryan, & Leonard, 2000; Caplan, DeDe, Waters, Michaud, & Tripodis, 2011)	A visual version of self-paced listening. At the beginning of each sentence, the words are represented by dashes. The participant pushes a button in order to begin reading the sentence, and is presented with the first word or segment. The participant pushes a button to indicate that they are done reading each segment, at which point the next segment appears and the previous segment disappears.	Reading times from the time that the participants push the button. Longer reading times indicate difficulty with processing or integration of information.
<b>Event-Related Action Potentials (ERP)</b> (e.g., Federmeier & Kutas, 2005; Steinhauer, Abada, Pauker, Itzhak, & Baum, 2010)	Participants wear electrodes that are externally attached to the scalp. The electrodes measure electrical activity in the brain while the participants listen to or read sentences.	Negative or positive waveforms are measured at windows of time from the presentation of critical words. One example is the N400, which refers to a negative going waveform that typically occurs 400 milliseconds after the onset of the critical word. The N400 effect is sensitive to the “fit” between a target word and the sentential context. Another example is the P600, which is sensitive to the presence of grammatical violations.

## Box 1. (continued)

Method	Description	Measurement
<b>Eyetracking while reading</b> (e.g., Kemper & Liu, 2007; Rayner, Reichle, Stroud, Williams, & Pollatsek, 2006)	Participants read sentences on a computer screen while a camera records their eye movements.	This method provides many different measures, including fixation times and regressions. Longer first fixation times (the amount of time spent looking at specific words before moving one's eyes) are typically indicative of initial difficulty in processing individual words or phrases. Measures such as regressions (looking back to parts of sentences that were previously read) indicate that the reader is trying to build an alternate structure.
<b>Crossed-Modal Lexical Priming (CMLP)</b> (e.g., Zurif, Swinney, Prather, Wingfield, & Brownell, 1995)	Participants listen to sentences and make lexical decisions about visually presented letter strings presented at a critical region of the sentences (e.g., the embedded verb in a relative clause). Real words may be semantically related or unrelated to critical sentence segments, such as the extracted noun phrase in a relative clause.	RTs from the time that the participant makes a lexical decision. Priming effects are interpreted as evidence that the participant has reactivated the critical segment (e.g., extracted noun phrase in an object relative sentence) at the point in the sentence when the visual stimulus was presented (e.g., the embedded verb).

Federmeier, Kutas, & Schul, 2010; Federmeier, McLennan, De Ochoa, & Kutas, 2002; Wlotko & Federmeier, 2012; Wlotko, Federmeier, & Kutas, 2012; also cf. DeLon, Groppe, Urbach, & Kutas, 2012). An example of a sentence in the highly constraining condition was “*No one at the reunion recognized Dan because he had grown a beard.*” An example in the weakly constraining context was “*At the children’s park next to the beach she saw a man with a beard.*” In Federmeier and Kutas’s (2005) study, the N400 effect refers to a difference in the magnitude of the waveform in strongly and weakly constraining contexts at the critical word, which is underlined in the examples. Federmeier and Kutas (2005) reported that the magnitude of the N400 effect differed as a function of age group and context. Older and younger adults showed similar N400 effects in weakly constraining contexts, but the younger adults showed a larger N400 effect than older adults in the strongly constraining contexts. The N400 effect was also delayed in older

**Box 2.** A brief definition of working memory

Working memory is a cognitive system that maintains information in an active state for a limited time so that it can be used to achieve some sort of goal directed behavior (Baddeley, 1992; Engle, 2001). For example, working memory is involved in mentally calculating a 20% tip on a restaurant bill. There are many different models of working memory (see, for example, Braver & West, 2008; Miyake & Shah, 1999). For the purposes of this chapter, two critical points are that the working memory system requires (1) active maintenance of important information and (2) a mechanism that identifies which information is important, allocates attention to maintain the activation of that information and minimizes interference from competing information.

Another important point is that working memory is a limited capacity system, meaning that there is an upper limit on how much information can be actively maintained at one time. There is significant individual variability with respect to how much information can be maintained. Consider a task in which a research participant is read a list of words and must repeat the list after mentally rearranging the words in alphabetical order. This task requires that the target words be actively maintained while being alphabetized. Caplan et al. (2011) found that adults between the ages of 18 and 30 could correctly repeat an average of 4.5 words. However, individual participants repeated as few as 3 and as many as 7 words correctly. Working memory capacity also appears to decrease as a function of normal aging. In the same study, adults between the ages of 70 to 90 alphabetized and repeated an average of 3.6 words (range 2 to 5 words).

adults compared to younger adults, suggesting that processing speed may contribute to the timing of the predictability effect. Although this study used word-by-word presentation (~2 words per second), similar effects have been reported using more naturalistic, spoken sentences (Federmeier et al., 2002). These types of data suggest that, as a group, older adults have more difficulty using sentential context to predict upcoming words in a sentence.

Federmeier and colleagues (e.g., 2002, 2005, 2010) also explored the extent to which neuropsychological variables such as verbal working memory capacity (see Box 2) and verbal fluency influenced the N400 effects. Verbal fluency refers to a task in which participants are required to generate as many items from a given category (e.g., animals) as possible within one minute. Older adults with higher performance on verbal fluency tasks showed N400 effects more similar to those shown by younger adults, suggesting that older adults with better performance on verbal fluency tasks are better able to predict upcoming words in a sentence (Federmeier et al., 2002). However, the relationship between verbal fluency and N400 magnitude is not consistent across studies (cf. Federmeier & Kutas, 2005). There is also evidence that older adults with higher verbal working memory capacity showed earlier sensitivity to the manipulation of predictability, as evidenced by the latency of the N400 effect (Federmeier & Kutas, 2005).

Taken together, these findings suggest that older adults who perform better on verbal fluency tasks or who have higher working memory capacity may show fewer age-related changes in the ability to predict upcoming words in sentences.

The behavioral and ERP studies seem to show inconsistent results. The behavioral studies suggest that older adults are able to use predictability information (e.g., Sheldon et al., 2008), whereas the ERP studies suggest that both the time course and magnitude of effects differ as a function of age (e.g., Federmeier & Kutas, 2005). Task differences may account for the discrepant results. In eyetracking, participants can control how much time they spend reading each word in the sentence. In contrast, Federmeier and Kutas (2005) used rapid serial visual presentation, with words presented for 200 ms followed by a 300 ms blank screen. It is possible that older adults use predictability in more naturalistic situations, or when they can control their own reading pace. Support for this view comes from a study by Janse, van der Werff, and Quené (2007). Janse and colleagues (2007) found that older adults were able to use contextual cues when speech was presented at relatively slow rates. They asked older and younger adults to identify target words in sentences, which were time-compressed to be 67% and 50% of the originally recorded duration. The sentences were either semantically unpredictable but plausible, or implausible. At the moderate speech rate (67%), older adults recognized words more quickly in meaningful than meaningless sentences. However, they did not show an effect of sentence context at the faster (50%) speech rate, suggesting that they could not integrate the semantic content of the sentence quickly enough to use it for prediction. In contrast, younger adults showed semantic facilitation at both speech rates. This finding is consistent with the claim that older adults use predictive contexts only when presentation rates permit sufficient processing time.

## Word order

A large number of studies about sentence comprehension in normally aging adults have focused on how older and younger adults parse syntactically complex and simple sentences. These types of studies aim to understand how people build a mental representation of the sentence, including the relationships between the words in the sentence and the meaning of the sentence. In this section, we will discuss why certain types of sentences tend to be more difficult to comprehend, and possible reasons why older adults encounter difficulties more often than their younger counterparts.

Studies about syntactic complexity frequently focus how older and younger adults process sentences with object and subject relative clauses (e.g., Caplan,

DeDe, Waters, Michaud, & Tripodi, 2011; Zurif, Swinney, Prather, Wingfield, & Brownell, 1995; Stine-Morrow et al., 2000). In English, sentences with object relative clauses (e.g., *The girl who the boy chased hugged her mother*) are more difficult to understand than sentences with subject relative clauses (e.g., *The girl who chased the boy hugged her mother*). Studies of college-aged adults reveal that processing is slower and less accurate when reading or listening to sentences with object- versus subject-extracted relative clauses (e.g., Gibson, Desmet, Grodner, Watson, & Ko, 2005; Gordon, Hendrick, Johnson, & Lee, 2006). The differences in processing speed can be localized to particularly demanding parts of the sentence, such as the embedded verb in an object relative sentence (*chased*, in the examples above). These differences, known as syntactic complexity effects, reflect the increased processing demand associated with complex (e.g., object relative) compared to relatively simple (e.g., subject relative) structures.

Syntactic complexity effects can be explained in several different ways. First, object relatives violate the canonical SVO word order of English. Furthermore, understanding these types of sentences requires that readers or listeners recognize the association between the extracted noun (e.g., *the girl*) and both verbs (e.g., *hugged* and *chased*). There is a greater distance between the extracted noun and the relative clause verb (*chased*) in object than subject relatives (Gibson, 1998). That is, “*the boy*” comes between “*the girl*” and “*chased*” in the object relative sentences, but not the subject relative sentences. There are also increased integration costs in object relatives because the subject of the relative clause intervenes between the extracted noun and relative clause verb. Finally, object relative clauses may be more difficult to understand because they occur less frequently than subject relative clauses. When thinking about effects of age and syntactic complexity, it is important to remember that older adults generally have slower response times than younger adults. As a result, the important question is whether the *difference* between simple and complex sentences is greater in older adults than younger adults. That is, absolute differences as a function of age or sentence type are less important than interactions between age and sentence type.

Early studies of sentence comprehension ability in normally aging adults tended to use only offline measures, such as comprehension accuracy. One early study did not report effects of age on sentence comprehension ability. Feier and Gerstman (1980) asked participants (18–80 years of age) to listen to sentences and then act out the scenarios using action figures. The stimuli included sentences with a range of complexity, including relative clause sentences, passives, and conjoined sentences (two sentences that are joined by a conjunction, such as “but” or “and”). As predicted, all listeners made more errors enacting scenarios from object relative sentences than subject relative sentences. Older adults also made more errors than younger adults. However, there were not any significant

interactions between age and sentence type, suggesting that complexity effects were similar across age.

In contrast, Obler, Fein, Nicholas, and Albert (1991) reported that older adults showed greater effects of syntactic complexity than younger adults. Participants (aged 30 to 79) listened to plausible and implausible sentences and answered yes-no questions about them. The sentences consisted of various simple and complex sentences, including passives, actives, relative clauses, doubly-embedded relative clauses (e.g., *The boy that kissed the girl that was wearing blue lived next door*) and comparatives (e.g., *The boy was bigger than the girl*). All participants took longer to answer questions about syntactically complex and implausible sentences. In addition, the older adults took longer to answer the questions than the younger adults. However, response times for the different age groups did not differ as a function of complexity or plausibility. The accuracy data showed a different pattern. Compared to younger adults, older adults made more errors overall and showed greater effects of syntactic complexity. The authors concluded that while there was a general age-related decline in processing ability for all sentence types, the decline was more gradual for simple sentences (such as active sentences), and that a more abrupt decline arose for the more complex sentences (i.e., sentences with double negation, comparatives, and doubly embedded relative clause sentences). This abrupt decline was present in participants in their 60s and 70s. These data suggest that even though syntactic processing generally declines with age, some sentence structures are more vulnerable to age effects. This may be due to syntactic properties of the sentences themselves or to the frequency with which certain structures occur in English.

More recent work has included both online and offline measures of sentence processing (see Box 1). Many of these studies have focused on whether declines in working memory capacity (see Box 2) or other age-related changes in general cognitive ability account for age-related changes in sentence comprehension ability. There is general agreement that working memory contributes to some aspects of sentence comprehension. For example, working memory capacity correlates with accuracy scores on questions probing comprehension of sentences (e.g., DeDe, Caplan, Kemtes, & Waters, 2004). This is probably because answering a comprehension question requires that the meaning of the target sentence be maintained in working memory while it is compared to the comprehension probe.

It is more controversial whether working memory is involved in online sentence processing (e.g., Caplan & Waters, 1999; Caplan & Waters, 2013; Just & Carpenter, 1992). In one study, Zurif and colleagues (1995) used a cross-modal lexical priming study to investigate how older adults assign syntactic structure and thematic roles to subject and object relative sentences. The older adults showed priming effects at the critical regions in subject relative sentences but not in object

relative sentences. However, older participants did show the expected priming effects in sentences with shorter object relative clauses. This led the authors to conclude that a decline in working memory capacity was the primary contributor to older adults' sentence processing deficits. However, Zurif et al. (1995) did not directly compare older and younger adults' syntactic processing and did not directly measure working memory capacity, making it somewhat difficult to interpret their results.

Waters and Caplan (2001, 2005) also investigated the relationship between working memory capacity and sentence processing in older adults. In their 2001 study, participants aged 18 to 80+ years listened to subject-cleft (e.g., *It was the girl who chased the boy last Sunday*) or object-cleft sentences (e.g., *It was the girl who the boy chased last Sunday*) in a self-paced listening paradigm (Waters & Caplan, 2001). Participants made a semantic acceptability judgment about each sentence. In general, older adults had longer listening times than younger adults. More importantly, all groups had longer listening times for verbs in object-cleft compared to subject-cleft sentences. This effect was largest in the groups of participants who were 50 to 59 years of age and those 80 years of age and older. The lack of systematic change across age groups suggests that age alone probably does not account for the processing changes. There was, however, a sentence type effect observed only in the oldest group. The 80 and older group had longer reaction times for the second noun phrase in cleft-subject sentences, suggesting that they needed more time to integrate information at the end of the sentences. Because the verbs in the cleft-object sentences and the second noun phrase in the cleft-subject sentences both occur at the end of the sentence, the results suggest that adults over the age of 80 require more time to integrate the information at the end of sentences.

Waters and Caplan (2005) also used self-paced listening to study how older and younger adults process sentences with object and subject relative clauses. The older adults were generally slower than the younger adults. All groups showed longer listening times for the verbs in object compared to subject relative clauses, but there were no significant differences due to age. These types of results are consistent with theories (e.g., Salthouse, 1991) that assume a general slowing effect due to aging, but not with theories that postulate age-related changes in syntactic processing ability per se. Importantly, neither Waters and Caplan (2005) nor Waters and Caplan (2001) reported a relationship between working memory capacity and effects of syntactic complexity for critical segments of the sentence.

DeDe and colleagues (2004) used structural equation models to examine the relationship between age and working memory on the one hand, and online, end-of-sentence, and discourse level comprehension on the other. They found that older age was associated with larger syntactic complexity effects, but the effect was not modulated by verbal working memory capacity. A different pattern was

found for the end-of-sentence and discourse level measures, where the effects of age were mediated by differences in verbal working memory capacity. That is, age had a direct effect on online listening times but not on performance on end-of-sentence and text level comprehension. DeDe et al. interpreted the results as evidence that age-related declines in working memory capacity contributed to end-of-sentence and text level effects, but that online sentence processing was not related to verbal working memory capacity.

Reading studies have found somewhat different effects of aging and working memory. Kemper, Crow, and Kemtes (2004) used a slightly different structure to investigate differences in older and younger adults' sentence processing. They used eyetracking during reading to examine resolution of temporary syntactic ambiguity in reduced relative clause sentences. Reduced relative clause sentences contain relative clauses in which a complementizer (e.g., *that*) and a verb (e.g., *were*) have been omitted. An example of a reduced relative clause sentence from Kemper et al. (2004) is "*The experienced soldiers warned about the dangers conducted the midnight raid.*" Reduced relative clause sentences often result in "garden path" effects, in which an initial misanalysis of the sentence must be corrected. In the example sentence, people often interpret *warn* as the main verb of the sentence. When they encounter the actual main verb (in this case, *conducted*), they must reinterpret the phrase *warned about the dangers* as a relative clause. That is, the comprehender must realize that it was "*the experienced soldiers that were warned about the dangers*" rather than "*the experienced soldiers*" warning someone else. Kemper and colleagues found that younger readers made similar numbers of regressive eye movements in both ambiguous and unambiguous sentences. In contrast, older readers made more regressions to the first noun phrase when reading ambiguous sentences compared to unambiguous sentences. However, the regressions to the first noun phrase did not significantly affect total fixation time. According to Kemper and colleagues, this suggested that older adults did not engage in significant reanalysis of the sentence, but employed more regressions in order to confirm their analysis. A follow-up experiment suggested that the apparent age differences were due to age-related differences in working memory capacity. This explanation is consistent with theories that assume that age-related processing changes are due to general cognitive factors as opposed to pure syntactic processing difficulty. Importantly, working memory was linked to reanalysis/reinterpretation rather than to building the initial interpretation of the sentence (cf. Caplan & Waters, 2013).

Later studies provided further support for the idea that cognitive factors are important for reanalysis or reinterpretation during sentence comprehension. Kemper and Liu (2007) used eyetracking to compare reading of object and subject cleft sentences. When the sentences were unambiguous (experiment 1), older and

younger adults' eye movements differed only in later measures such as regressive eye movements, regression path duration, and total reading times. This pattern suggests that the effects of age and working memory reflect older adults' difficulty resolving both temporary ambiguities and misanalyses associated with sentence processing. In experiment two, Kemper and Liu created ambiguous versions of sentences with object relative clauses by omitting the complementizer "that." Both younger and older adults had significantly more difficulty processing sentences without the disambiguating "that." There was a significant interaction in which the older adults had more difficulty with the ambiguous sentences than young adults. Taken together, these data suggest that older adults spent more time reanalyzing the sentences when they encountered the embedded verb. Kemper and Liu suggested that age-related declines in working memory capacity accounted for the additional time spent in reanalysis of the syntactically complex sentences.

Caplan and colleagues (2011) used self-paced reading to examine the relationship between age, working memory, speed of processing, and syntactic processing. In experiment one, participants made plausibility judgments about sentences with subject and object relative clauses. In a second experiment, participants answered comprehension questions about sentences with doubly embedded relative clause sentences (e.g., *The dealer who the jewelry that was identified by the victim implicated was arrested by the police*) and sentences with sentential complements (e.g., *The dealer indicated that the jewelry that was identified by the victim implicated one of his friends*). Age was negatively correlated with accuracy on syntactically complex sentences, such as sentences with object relative clauses and doubly embedded sentences. All participants spent more time reading the most demanding segments of syntactically complex sentences. In addition, Caplan and colleagues reported the crucial interaction between sentence type and age. Older adults had significantly longer reading times than younger adults at the verbs in all sentence types except for the subject cleft and subject relative sentences, which were syntactically the simplest sentence types. The effects of syntactic complexity correlated with measures of working memory capacity for the most demanding sentence types (doubly embedded sentences). Caplan and colleagues suggested that working memory did not account for age effects in less demanding structures, even those with object relative clauses. Instead, general working memory capacity only contributed to comprehension of the most difficult sentences (i.e., doubly embedded sentences), possibly due to task differences associated with answering comprehension questions in experiment two.

Caplan et al. (2011) also investigated the relationship between online and offline measures of sentence comprehension. They asked whether spending more time on complex segments of a sentence was associated with better comprehension. To do so, they correlated syntactic complexity effects (i.e., reading times

for demanding portions of complex vs. simple sentences) with accuracy on the end-of-sentence acceptability judgment task. The results suggested that spending more time reading the most demanding portions of sentence improved older adults' performance on comprehension tasks. This type of result suggests that age-related changes in sentence comprehension may reflect reallocation of processing resources in response to comprehension difficulty (cf. Stine-Morrow, Miller, & Hertzog, 2006).

Stine-Morrow and her colleagues have focused on the idea that older adults allocate processing resources differently than younger adults during cognitively demanding tasks (e.g., Stine-Morrow, Loveless, & Soederberg, 1996; Stine-Morrow et al., 2006). On this account, readers may allocate processing resources differently in the face of increasing cognitive demands. In this context, allocation of processing resources is often operationalized as more time spent reading part of a sentence, with the implication that more time indicates increased effort. Critically, this reallocation of resources may not be conscious, meaning that readers or listeners are not always aware that they are making changes. With respect to language processing, this means that people adjust the allocation of processing resources based on the difficulty of the computations needed to support comprehension. Older adults may be able to compensate for declining sentence comprehension ability by spending more time on difficult segments of the sentence. However, comprehension failures might result when the processing demands of a particular structure outstrip the processing resources available to an older adult.

For example, Stine-Morrow and colleagues (2000) described a self-paced reading study in which younger and older adults read subject relative and object relative sentences. The younger adults had longer reading times at critical regions in object relatives compared to subject relatives (the relative clause verb and relative clause noun). In contrast, older adults displayed longer reading times for the critical regions compared to other parts of the sentence, but did not show a significant effect of sentence type. In addition, older adults answered comprehension questions about object relative sentences significantly less accurately than younger adults. This difference was not observed in comprehension questions about subject relative sentences. This pattern led Stine-Morrow and colleagues to hypothesize that the younger adults allocated processing resources more effectively, allowing them to understand the sentences. In contrast, when reading object relatives, older adults "gave up" before they had completed the processes required to build the more complex structure (also cf. Brébion, 2001 & 2003).

We have discussed two accounts of age-related changes in sentence comprehension ability: declining working memory capacity and reallocation of resources. However, it is important to realize that these accounts are not necessarily mutually exclusive. For example, older adults may need to allocate processing

resources differently than younger adults due to declining working memory capacity. Many of the studies that focus on working memory are also consistent with Stine-Morrow et al.'s (2006) claim that older adults compensate for age related declines in comprehension ability by reallocating processing resources.

### **Effects of sensory acuity on sentence comprehension ability in older adults**

So far, we have focused on how linguistic variables affect sentence comprehension. However, the capacity to understand sentences is dependent on the ability to recognize an auditory or visual signal. Thus, the effects of the variables considered above (word recognition, predictability, and word order) may be influenced by age-related changes in sensory acuity. According to the effortfulness hypothesis (Rabbitt, 1991; Tun, McCoy, & Wingfield; 2009; Wingfield, Tun, & McCoy, 2005), age-related changes in sensory acuity make it more difficult for older adults to complete low-level processing of auditory and visual information. To compensate, older adults may recruit additional resources to help process the stimulus. By drawing processing resources away from higher-level cognitive operations, this need to compensate for changes in acuity may result in difficulty understanding words or sentences. This account does not assume that older adults have difficulty comprehending sentences *per se*. Instead, the idea is that lower level perceptual operations draw processing resources away from syntactic parsing operations, leading to increased comprehension difficulty.

#### **Auditory acuity**

Age-related hearing loss, known as presbycusis, is estimated to affect approximately 45% of adults aged 60 to 70 and 68% of adults older than 70 years (Lin, Niparko, & Ferrucci, 2011). Presbycusis, which often affects high frequency sounds to a greater extent than low frequency sounds, can lead to difficulty recognizing spoken words. However, even older adults with normal hearing thresholds have difficulty processing temporal cues associated with speech (e.g., gap detection), which may contribute to difficulty recognizing words (Gordon-Salant & Fitzgibbons, 1995). Older adults are also disproportionately affected by adverse listening conditions, such as recognizing words that are presented in noisy environments (e.g., Pichora-Fuller & Souza, 2003) or at fast speech rates (Wingfield, McCoy, Peelle, Tun, & Cox, 2006). Even with hearing aids, older adults with hearing loss have more difficulty processing speech in environments with multiple

competing talkers or other types of background noise (e.g., Marrone, Mason, & Kidd, 2008).

Studies about the perception of speech in noise typically involve auditory presentation of sentences, some of which have been manipulated to increase perceptual difficulty. Perceptual difficulty may be increased by presenting sentences in the presence of different types of background noise (e.g., Carroll & Ruigendijk, 2013), by temporally compressing speech (Janse, 2009; Wingfield et al., 2006), or by decreasing the intensity level of the stimulus (e.g., Stewart & Wingfield, 2009). The critical questions are whether (1) increasing perceptual difficulty affects comprehension in younger adults, (2) there is an additional cost of being an older adult, and (3) there is an additional cost of having hearing loss. In this context, cost refers to the idea that the effect of perceptual difficulty would be greater in one population than another. Here we focus on the second question, which is whether older adults are disproportionately affected by perceptual difficulty, as compared to younger adults.

Some studies have reported that aging effects on word recognition are minimized when older and younger adults are matched for hearing sensitivity, or at more favorable signal to noise ratios (Gordon-Salant & Fitzgibbons, 1995; Pichora-Fuller et al., 1995; Souza & Turner, 1994). This type of finding suggests that differences in older and younger adults' ability to understand speech in natural environments at least partly reflects differences in hearing sensitivity. However, as Pichora-Fuller and Souza (2003) pointed out, adjusting audibility is only effective in simple tasks with simple stimuli.

There is also evidence that older adults show a greater cost than younger adults when processing complex sentences under adverse listening conditions. In one study, older and younger adults with clinically normal hearing and with mild-moderate hearing losses listened to syntactically simple (subject relative) and complex (object relative) sentences (Wingfield et al., 2006). The sentences were presented at four speech rates: 205 words per minute (wpm), 258 wpm, 321 wpm, and 410 wpm. The stimuli were recorded at the lowest speech rate (205 wpm) and then time compressed to achieve the higher speech rates. For the relatively simple sentences, all of the groups achieved at least 85% accuracy across all of the speech rate conditions. However, both older and younger adults with hearing loss had more difficulty understanding sentences presented at rapid speech rates. In contrast, participants with clinically normal hearing did not show a significant decline in comprehension as speech rate increased. Individuals with hearing loss also had more difficulty comprehending the more complex object relative sentences at faster rates of speech. In addition, older adults performed more poorly on the comprehension task at faster speech rates. Older adults with hearing loss

were disproportionately affected by increasing speech rate, suggesting that both age and hearing acuity contributed to difficulty comprehending complex sentences. Taken together, these results show that both syntactic complexity and hearing loss can contribute to declining sentence comprehension ability in older adults. More recently, Stewart and Wingfield (2009) reported very similar results when they used decreased audibility rather than time compression to degrade the quality of the auditory stimulus (also see Tun et al., 2009). These types of data suggest that increasing perceptual difficulty has a negative effect on both word recognition and sentence comprehension.

### Visual acuity

Less attention has been paid to the impact of changes in visual acuity on language comprehension. In addition to affecting written communication, visual acuity could affect spoken language comprehension by influencing the accessibility of visual spoken language cues. Presbyopia, which affects everyone beginning in mid-life, refers to age-related declines in the ability to focus on near objects (National Eye Institute, <<https://www.nei.nih.gov/>>). In addition, normal aging is associated with increased difficulty seeing under low illumination and a decline in sensitivity to spatial frequencies under photopic (well-lit) conditions (Owsley, 2011).

To date, few studies have examined how visual acuity affects reading comprehension in older adults. Nonetheless, there is some evidence that increasing the perceptual difficulty of visually presented stimuli affects both word and sentence level processes. First, basic perceptual characteristics such as font influence both older and younger adults' reading times (e.g., Rayner et al., 2006). Both age groups read more slowly when sentences were presented in Old English compared to Times New Roman font, but the penalty associated with reading an atypical font was greater in older adults than younger adults. In addition, reducing the contrast between the foreground and background for printed words is associated with a reduction in speed and accuracy of oral reading in both normally aging adults and adults with Alzheimer's disease (Cronin-Golomb, Gilmore, Nearing, Morrison, & Laudate, 2007). Cronin-Golomb et al. (2007) digitally filtered visually presented words to manipulate the spatial contrast of the stimuli. Older adults showed greater reductions than younger adults in reading accuracy and speed in the lower contrast conditions, and individuals with Alzheimer's disease showed greater reductions than normally aging adults. Taken together, these findings suggest that written lexical access is more challenging when stimuli are presented

under less favorable viewing conditions, and that the processing costs associated with visual perceptual difficulty are greater for older adults than younger adults.

At the sentence level, Gao, Levinthal, and Stine-Morrow (2012) investigated whether older adults would have more difficulty than younger adults recalling paragraphs presented in the presence of visual noise. Gao et al. created visual noise by setting some of the pixels in the visual display to a randomly selected grey scale value. In the first experiment, visual noise was manipulated within a rather moderate range (30%, 50%, or 70% of pixels). The authors examined how the three levels of visual noise affected allocation of resources to word-level (frequency, syllable length) and text level (e.g., cumulative conceptual load) features of two-sentence passages. The authors used regression analyses to obtain a measure of the processing resources (time) allocated to word and text level features of the passages. At higher levels of visual noise, older adults tended to allocate more processing resources to word-level features of the passages and to spend less time processing text level features. Older adults also showed poorer recall of the passages. Younger adults did not show the same pattern of effects at the moderate levels of visual noise. However, this pattern of resource reallocation was observed in younger adults when stimuli were presented under more extreme levels of visual noise (i.e., when 80% of the pixels were set to grey scale).

Changes in visual acuity may also affect auditory comprehension. Numerous studies have documented better perception and comprehension in audio-visual communication (e.g., speech reading) as compared to either modality alone (e.g., Sommers, Tye-Murray, & Spehar, 2005). A few research groups have investigated whether older and younger adults show differential benefits of multisensory input during sentence-level comprehension (Gordon & Allen, 2009; Maguinness, Setti, Burke, Kenny, & Newell, 2011; also cf. Tye-Murray, Spehar, Myerson, Sommers, & Hale, 2011). This body of work suggests that older adults show improved speech recognition and auditory comprehension when the auditory signal is accompanied by a clear visual stimulus (e.g., Walden, Busacco, & Montgomery, 1993; Sommers et al., 2005). Further, the older adults showed greater benefits of multisensory input than younger adults, but only when the visual stimulus was presented under advantageous viewing conditions. Indeed, some studies have reported that presenting an auditory stimulus with a degraded visual stimulus confers no processing advantage over unimodal auditory presentation (e.g., Tye-Murray et al., 2011).

Studies about age-related declines in auditory and visual acuity are consistent with the effortfulness hypothesis (Rabbitt, 1991; Tun et al., 2009; Wingfield et al., 2005). When auditory or visual stimuli are more difficult to decode, older adults have more difficulty comprehending sentences than younger adults do. Research

from the auditory domain suggests that the effect of perceptual difficulty is greater in more demanding tasks (recalling the entire sentence vs. recalling the last word of the sentence) and more demanding sentence structures (object vs. subject relative). Finally, older adults show a benefit for multisensory (auditory plus visual) presentation when the visual cue is not degraded in some way. Although further research is needed on the topic of auditory-visual integration, it seems that having a strong visual cue minimizes the extent to which a perceptually challenging auditory stimulus competes for cognitive resources.

### Older adults as language experts

Most of the existing research focuses on the idea that older adults process sentences more slowly and effortfully than younger adults. However, consider the idea that older adults reallocate processing resources to compensate for age-related declines in comprehension ability. This reallocation may be viewed as a positive strategy, which balances effort with the likelihood of comprehension success. There is evidence that older adults use their language expertise to avoid some processing disruptions. Previous studies have shown that expertise in a specific domain (e.g., aviation) can mitigate age-related changes in memory for spoken and written language (e.g., Morrow, Menard, Stine-Morrow, Teller, & Bryant, 2001; Soederberg Miller, 2001). One possibility is that older adults reallocate processing resources not by slowing down, but by using what they know about their language to facilitate comprehension.

Rayner and colleagues (2006) suggested that older adults use “riskier” processing strategies than younger adults. On this account, older adults rely on their experience-based knowledge of language to generate predictions about upcoming words in a sentence. Correct predictions facilitate sentence comprehension, but incorrect predictions slow the mental operations involved in recognizing words and constructing a mental representation of the sentence (i.e., determining *who did what to whom*). Risky strategies have been shown to affect lexical processes in the context of written sentences (Rayner et al., 2006), as well as how older adults construct a mental representation of *who did what to whom* in a sentence (DeDe, 2014).

DeDe (2014) showed that risky processing strategies apply to sentence level comprehension. Older and younger adults read late closure sentences such as “*When the waiter served the woman the food was still too hot.*” In some sentences, the subordinate verb could occur in ditransitive constructions (e.g., *the waiter*

served the woman the food). In this condition, the noun phrase “*the food*” is ambiguous in that it could be a continuation of the subordinate clause (i.e., what the waiter served) or the subject of the main verb (i.e., what was hot). The correct interpretation of “*the food*” becomes clear at the main verb (*was*). Sentences with optionally ditransitive verbs were compared with sentences containing verbs that cannot occur in ditransitive constructions (e.g., *When the waiter kissed the woman the food was still too hot.*). The results suggested that older adults relied on the verb’s characteristics (i.e., whether it could occur in ditransitive constructions) to a greater extent than younger adults, because they showed no processing disruptions in sentences with verbs such as “*kissed*.” However, when their initial interpretation was incorrect, they showed a greater processing disruption than the younger adults (at the main verb in the “*served*” case). This strategy is risky because when the verb’s characteristics are inconsistent with the sentence structure, reading times were more disrupted in older than younger adults.

A somewhat similar perspective is that older adults rely on processing heuristics to a greater extent than younger adults (Christianson, Williams, Zacks, & Ferreira, 2006). This perspective emerged from work on so-called “Good enough” sentence processing, which refers to the idea that comprehenders do not always achieve a completely correct, literal interpretation of sentences (i.e., Christianson, Hollingworth, Halliwell, & Ferreira, 2001). For example, readers might maintain multiple interpretations of a sentence such as “*While Anna dressed the baby played in the crib.*” In this example, readers may conclude that Anna both dressed herself and the baby. This phenomenon is particularly evident when the syntax of the sentence does not explicitly rule out the inference, such as in “*When the man hunted the deer ran into the forest.*” Here, it is very plausible to think that both the man was hunting the deer and that the deer was running. Christianson et al. (2006) reported that both older and younger adults retained incorrect inferences in the “*dress*” case, where the syntax rules out the alternative interpretation, and the “*hunt*” case, where the syntax does not rule it out. Interestingly, older adults retained more incorrect inferences than younger adults in the “*hunted*” case, but the age groups did not differ in the “*dress*” case. The authors suggested that older adults had more difficulty revising an initial interpretation of the temporarily ambiguous sentences, and so settled for a good enough interpretation, particularly when it was not incompatible with the syntax.

At present, there are few studies investigating the role of linguistic expertise in older adults’ sentence comprehension. Further work is needed in this area to fully describe the contexts in which older adults use their linguistic expertise to improve comprehension.

## Conclusions

Taken together, most studies of sentence comprehension in normally aging adults suggest that older adults work harder to achieve the same or reduced levels of comprehension. In research studies, “working harder” is typically operationalized as taking longer. There are many candidate reasons for why older adults must work harder, including declines in working memory capacity and perceptual acuity. With respect to working memory, there is some evidence that working memory is involved in aspects of generating predictions for upcoming words based on the semantic content of a sentence (e.g., Federmeier et al., 2002, 2005, 2010). Other work suggests that working memory may be involved in syntactic operations related to recovering from misanalyses of sentences (e.g., Kemper et al., 2004) or coping with the memory demands associated with comprehension questions (Caplan et al., 2011).

Perceptual acuity may contribute to sentence comprehension ability, as predicted by the effortfulness hypothesis. However, studies in this area of research have been limited to offline measures of sentence comprehension, which makes it difficult to know how acuity affects the syntactic parsing operations involved in building a mental representation of a sentence.

Finally, there is evidence that older adults compensate for age-related changes in comprehension ability by allocating processing resources differently than younger adults, and by using their knowledge of language to mitigate age-related changes. Further research is needed to fully describe both the mechanisms of age-related decline in comprehension ability and the ways in which older adults compensate for those declines.

## References

- Baddeley, A. (1992). Working memory. *Science*, 255(5044), 556–559.  
doi:10.1126/science.1736359
- Balota, D. A., Pollatsek, A., & Rayner, K. (1985). The interaction of contextual constraints and parafoveal visual information in reading. *Cognitive Psychology*, 17(3), 364–390.  
doi:10.1016/0010-0285(85)90013-1
- Balota, D. A., Yap, M. J., & Cortese, M. J. (2006). Visual word recognition: The journey from features to meaning (A travel update). In M. Traxler & M. A. Gernsbacher (Eds.), *Handbook of psycholinguistics* (pp. 285–375). San Diego, CA: Academic Press.  
doi:10.1016/B978-012369374-7/50010-9
- Braver, T. S., & West, R. (2008). Working memory, executive control, and aging. In F. I. M. Craik & T. A. Salthouse (Eds.), *The handbook of aging and cognition* (5th ed.; pp. 311–372). New York, NY: Psychology Press.

- Brébion, G. (2001). Language processing, slowing, and speed/accuracy trade-off in the elderly. *Experimental Aging Research*, 27, 137–150. doi:10.1080/036107301750073999
- Brébion, G. (2003). Working memory, language comprehension, and aging: Four experiments to understand the deficit. *Experimental Aging Research*, 29, 269–301. doi:10.1080/03610730303725
- Caplan, D., DeDe, G., Waters, G., Michaud, J., & Tripodis, Y. (2011). Effects of age, speed of processing, and working memory on comprehension of sentences with relative clauses. *Psychology and Aging*, 26(2), 439–450. doi:10.1037/a0021837
- Caplan, D. & Waters, G. S. (1999). Verbal working memory capacity and language comprehension. *Behavioral and Brain Science*, 22, 114–126. doi:10.1017/S0140525X99441780
- Caplan, D., & Waters, G. (2013). Memory mechanisms supporting syntactic comprehension. *Psychonomic Bulletin & Review*, 20, 243–268. doi:10.3758/s13423-012-0369-9
- Carroll, R., & Ruigendijk, E. (2013). The effects of syntactic complexity on processing sentences in noise. *Journal of Psycholinguistic Research*, 42(2), 139–159. doi:10.1007/s10936-012-9213-7
- Christianson, K., Hollingworth, A., Halliwell, J. F., & Ferreira, F. (2001). Thematic roles assigned along the garden path linger. *Cognitive Psychology*, 42(4), 368–407. doi:10.1006/cogp.2001.0752
- Christianson, K., Williams, C. C., Zacks, R. T., & Ferreira, F. (2006). Younger and older adults' "good-enough" interpretations of garden-path sentences. *Discourse Processes*, 42(2), 205–238. doi:10.1207/s15326950dp4202\_6
- Cronin-Golomb, A., Gilmore, G. C., Neargarder, S., Morrison, S. R., & Laudate, T. M. (2007). Enhanced stimulus strength improves visual cognition in aging and Alzheimer's disease. *Cortex*, 43(7), 952–966. doi:10.1016/S0010-9452(08)70693-2
- Dahan, D., & Magnuson, J. S. (2006). Spoken-word recognition. In M. J. Traxler & M. A. Gernsbacher (Eds.), *Handbook of psycholinguistics* (pp. 249–283). San Diego, CA: Academic Press. doi:10.1016/B978-012369374-7/50009-2
- DeDe, G. (2012). Effects of word frequency and modality on sentence comprehension impairments in people with aphasia. *American Journal of Speech-Language Pathology*, 21(2), S103–S114. doi:10.1044/1058-0360(2012/11-0082)
- DeDe, G. (2014). Sentence comprehension in older adults: Evidence for risky processing strategies. *Experimental Aging Research*, 40(5), 589–598. doi:10.1080/0361073X.2014.926775
- DeDe, G., Caplan, D., Kemtes, K., & Waters, G. S. (2004). The relationship between age, verbal working memory, and language comprehension. *Psychology & Aging*, 19, 601–616. doi:10.1037/0882-7974.19.4.601
- DeLong, K. A., Groppe, D. M., Urbach, T. P., & Kutas, M. (2012). Thinking ahead or not? Natural aging and anticipation during reading. *Brain and Language*, 121(3), 226–239. doi:10.1016/j.bandl.2012.02.006
- Drieghe, D., Rayner, K., & Pollatsek, A. (2005). Eye movements and word skipping during reading revisited. *Journal of Experimental Psychology: Human Perception and Performance*, 31(5), 954–969. doi:10.1037/0096-1523.31.5.954
- Engle, R. W. (2001). What is working-memory capacity? In H. L. Roediger III & J. S. Nairne (Eds.), *The Nature of Remembering: Essays in Honor of Robert G. Crowder* (pp. 297–314). Washington, DC: American Psychological Association. doi:10.1037/10394-016
- Federmeier, K. D. & Kutas, M. (2005). Aging in context: Age-related changes in context use during language comprehension. *Psychophysiology*, 42, 133–141. doi:10.1111/j.1469-8986.2005.00274.x

- Federmeier, K. D., Kutas, M., & Schul, R. (2010). Age-related and individual differences in the use of prediction during language comprehension. *Brain and Language*, 115, 149–161. doi:10.1016/j.bandl.2010.07.006
- Federmeier, K. D., McLennan, D. B., De Ochoa, E., & Kutas, M. (2002). The impact of semantic memory organization and sentence context information on spoken language processing by younger and older adults: An ERP study. *Psychophysiology*, 39, 133–146. doi:10.1111/1469-8986.3920133
- Federmeier, K. D., Van Petten, C., Schwartz, T. J., & Kutas, M. (2003). Sounds, words, sentences: Age-related changes across levels of language processing. *Psychology and Aging*, 18, 858–872. doi:10.1037/0882-7974.18.4.858
- Feier, C. D. & Gerstman, L. J. (1980). Sentence comprehension abilities throughout the adult life span. *Journal of Gerontology*, 35, 722–728. doi:10.1093/geronj/35.5.722
- Gao, X., Levinthal, B. R., & Stine-Morrow, E. A. (2012). The effects of ageing and visual noise on conceptual integration during sentence reading. *The Quarterly Journal of Experimental Psychology*, 65(9), 1833–1847. doi:10.1080/17470218.2012.674146
- Gibson, E. (1998). Linguistic complexity: Locality of syntactic dependencies. *Cognition*, 68, 1–76. doi:10.1016/S0010-0277(98)00034-1
- Gibson, E., Desmet, T., Grodner, D., Watson, D., & Ko, K. (2005). Reading relative clauses in English. *Cognitive Linguistics*, 16(2), 313–353. doi:10.1515/cogll.2005.16.2.313
- Gordon, M. S., & Allen, S. (2009). Audiovisual speech in older and younger adults: integrating a distorted visual signal with speech in noise. *Experimental Aging Research*, 35(2), 202–219. doi:10.1080/03610730902720398
- Gordon, P. C., Hendrick, R., Johnson, M., & Lee, Y. (2006). Similarity-based interference during language comprehension: Evidence from eye tracking during reading. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 32, 1304–1321. doi:10.1037/0278-7393.32.6.1304
- Gordon-Salant, S., & Fitzgibbons, P. J. (1995). Recognition of multiply degraded speech by young and elderly listeners. *Journal of Speech, Language and Hearing Research*, 38(5), 1150–1156. doi:10.1044/jshr.3805.1150
- Inhoff, A. W., & Rayner, K. (1986). Parafoveal word processing during eye fixations in reading: Effects of word frequency. *Perception & Psychophysics*, 40(6), 431–439. doi:10.3758/BF03208203
- Janse, E. (2009). Processing of fast speech by elderly listeners. *The Journal of the Acoustical Society of America*, 125, 2361–2373. doi:10.1121/1.3082117
- Janse, E., Van Der Werff, M., & Quené, H. (2007). Listening to fast speech: aging and sentence context. *Proceedings of the 16th International Congress of Phonetic Sciences*, 681–684.
- Just, M., & Carpenter, P. A. (1992). A capacity theory of comprehension: Individual differences in working memory. *Psychological Review*, 99, 122–149. doi:10.1037/0033-295X.99.1.122
- Kemper, S., Crow, A., & Kemtes, K. (2004). Eye-fixation patterns of high- and low-span young and older adults: Down the garden path and back again. *Psychology and Aging*, 19, 157–170. doi:10.1037/0882-7974.19.1.157
- Kemper, S., & Liu, C.-J., (2007). Eye movements of young and older adults during reading. *Psychology and Aging*, 22(1), 84–93. doi:10.1037/0882-7974.22.1.84
- Kliegl, R., Grabner, E., Rolfs, M., & Engbert, R. (2004). Length, frequency, and predictability effects of words on eye movements in reading. *European Journal of Cognitive Psychology*, 16(1–2), 262–284. doi:10.1080/09541440340000213

- Lin, F. R., Niparko, J. K., & Ferrucci, L. (2011). Hearing loss prevalence in the United States. *Archives of Internal Medicine*, 171(20), 1851–1852. doi:10.1001/archinternmed.2011.506
- Luce, P. A., & Pisoni, D. B. (1998). Recognizing spoken words: The neighborhood activation model. *Ear and Hearing*, 19, 1–36. doi:10.1097/00003446-199802000-00001
- Maguinness, C., Setti, A., Burke, K. E., Kenny, R. A., & Newell, F. N. (2011). The effect of combined sensory and semantic components on audio-visual speech perception in older adults. *Frontiers in Aging Neuroscience*, 3, 19. doi:10.3389/fnagi.2011.00019
- Marrone, N., Mason, C. R., & Kidd Jr, G. (2008). The effects of hearing loss and age on the benefit of spatial separation between multiple talkers in reverberant rooms. *The Journal of the Acoustical Society of America*, 124, 3064–3075. doi:10.1121/1.2980441
- Miyake, A., & Shah, P. (Eds.). (1999). *Models of working memory: Mechanisms of active maintenance and executive control*. Cambridge: Cambridge University Press. doi:10.1017/CBO9781139174909
- Morrow, D. G., Menard, W. E., Stine-Morrow, E. A., Teller, T., & Bryant, D. (2001). The influence of expertise and task factors on age differences in pilot communication. *Psychology and Aging*, 16(1), 31–46. doi:10.1037/0882-7974.16.1.31
- Obler, L. K., Fein, D., Nicholas, M., & Albert, M. L. (1991). Auditory comprehension and aging: Decline in syntactic processing. *Applied Psycholinguistics*, 12, 433–452. doi:10.1017/S0142716400005865
- Owsley, C. (2011). Aging and vision. *Vision Research*, 51(13), 1610–1622. doi:10.1016/j.visres.2010.10.020
- Pichora-Fuller, M. K., Schneider, B. A., & Daneman, M. (1995). How young and old adults listen to and remember speech in noise. *The Journal of the Acoustical Society of America*, 97, 593–608. doi:10.1121/1.412282
- Pichora-Fuller, M. K., & Souza, P. E. (2003). Effects of aging on auditory processing of speech. *International Journal of Audiology*, 42(S2), 11–16. doi:10.3109/14992020309074638
- Revill, K. P., & Spieler, D. H. (2012). The effect of lexical frequency on spoken word recognition in young and older listeners. *Psychology and Aging*, 27(1), 80–87. doi:10.1037/a0024113
- Rabbitt, P. M. A. (1991). Mild hearing loss can cause apparent memory failures which increase with age and reduce with IQ. *Acta Otolaryngologica, Supplementum*, 476, 167–176. doi:10.3109/00016489109127274
- Rayner, K., Reichle, E., Stroud, M., Williams, C., & Pollatsek, A. (2006). The effect of word frequency, word predictability, and font difficulty on the eye movements of young and older readers. *Psychology and Aging*, 21, 448–465. doi:10.1037/0882-7974.21.3.448
- Salthouse, T. A. (1991). Mediation of adult age differences in cognition by reductions in working memory and speed of processing. *Psychological Science*, 2, 179–183. doi:10.1111/j.1467-9280.1991.tb00127.x
- Salthouse, T. A. (1996). The processing-speed theory of adult age differences in cognition. *Psychological Review*, 103(3), 403–428. doi:10.1037/0033-295X.103.3.403
- Sheldon, S., Pichora-Fuller, M. K., & Schneider, B. A. (2008). Priming and sentence context support listening to noise-vocoded speech by younger and older adults. *The Journal of the Acoustical Society of America*, 123, 489–499. doi:10.1121/1.2783762
- Soederberg Miller, L. M. (2001). The effects of real-world knowledge on text processing among older adults. *Aging, Neuropsychology, and Cognition: A Journal on Normal and Dysfunctional Development*, 8(2), 137–148

- Sommers, M., Tye-Murray, N., & Spehar, B. (2005). Auditory-visual speech perception and auditory-visual enhancement in normal-hearing younger and older adults. *Ear and Hearing*, 26, 263–275. doi:10.1097/00003446-200506000-00003
- Souza, P. E., & Turner, C. W. (1994). Masking of speech in young and elderly listeners with hearing loss. *Journal of Speech, Language and Hearing Research*, 37(3), 655–661. doi:10.1044/jshr.3703.655
- Speranza, F., Daneman, M., & Schneider, B. A. (2000). How aging affects the reading of words in noisy backgrounds. *Psychology and Aging*, 15(2), 253–258. doi:10.1037/0882-7974.15.2.253
- Steinhauer, K., Abada, S. H., Pauker, E., Itzhak, I., & Baum, S. R. (2010). Prosody-syntax interactions in aging: Event-related potentials reveal dissociations between online and offline measures. *Neuroscience Letters*, 472(2), 133–138. doi:10.1016/j.neulet.2010.01.072
- Stewart, R., & Wingfield, A. (2009). Hearing loss and cognitive effort in older adults' report accuracy for verbal materials. *Journal of the American Academy of Audiology*, 20(2), 147–154. doi:10.3766/jaaa.20.2.7
- Stine-Morrow, E., Loveless, M. K., & Soederberg, L. M. (1996). Resource allocation in online reading by younger and older adults. *Psychology and Aging*, 11, 475–486. doi:10.1037/0882-7974.11.3.475
- Stine-Morrow, E., Miller, L. M. S., & Hertzog, C. (2006). Aging and self-regulated language processing. *Psychological Bulletin*, 132, 582–606. doi:10.1037/0033-2909.132.4.582
- Stine-Morrow, E., Ryan, S. & Leonard, J. S. (2000). Age differences in online syntactic processing. *Experimental Aging Research*, 26, 315–322. doi:10.1080/036107300750015714
- Taler, V., Aaron, G. P., Steinmetz, L. G., & Pisoni, D. B. (2010). Lexical neighborhood density effects on spoken word recognition and production in healthy aging. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 65(5), 551–560. doi:10.1093/geronb/gbq039
- Tun, P. A., McCoy, S., & Wingfield, A. (2009) Aging, hearing acuity, and the attentional costs of effortful listening. *Psychology and Aging*, 24, 761–766. doi:10.1037/a0014802
- Tye-Murray, N., Spehar, B., Myerson, J., Sommers, M. S., & Hale, S. (2011). Crossmodal enhancement of speech detection in young and older adults: Does signal content matter? *Ear and Hearing*, 32(5), 650–655. doi:10.1097/AUD.0b013e31821a4578
- Verhaeghen, P. (2003). Aging and vocabulary score: A meta-analysis. *Psychology and Aging*, 18(2), 332–339. doi:10.1037/0882-7974.18.2.332
- Walden, B. E., Busacco, D. A., & Montgomery, A. A. (1993). Benefit from visual cues in auditory-visual speech recognition by middle-aged and elderly persons. *Journal of Speech and Hearing Research*, 36(2), 431–436. doi:10.1044/jshr.3602.431
- Waters, G. S. & Caplan, D. (2001). Age, working memory and online syntactic processing in sentence comprehension. *Psychology and Aging*, 16, 128–144. doi:10.1037/0882-7974.16.1.128
- Waters, G. S., & Caplan, D. (2005). The relationship between age, processing speed, working memory capacity, and language comprehension. *Memory*, 13, 403–413.
- Wingfield, A., Alexander, A. H., & Cavigelli, S. (1994). Does memory constrain utilization of top-down information in spoken word recognition? Evidence from normal aging. *Language and Speech*, 37(3), 221–235.
- Wingfield, A., McCoy, S. L., Peelle, J. E., Tun, P. A., & Cox, C. L. (2006). Effects of adult aging and hearing loss on comprehension of rapid speech varying in syntactic complexity. *Journal of the American Academy of Audiology*, 17(7), 487–497. doi:10.3766/jaaa.17.7.4

- Wingfield, A., Tun, P. A., & McCoy, S. L. (2005). Hearing loss in older adulthood. What it is and how it interacts with cognitive performance. *Current Directions in Psychological Science*, 14(3), 144–148. doi:10.1111/j.0963-7214.2005.00356.x
- Wlotko, E. W. & Federmeier, K. D. (2012). Age-related changes in the impact of contextual strength on multiple aspects of sentence comprehension. *Psychophysiology*, 49, 770–785. doi:10.1111/j.1469-8986.2012.01366.x
- Wlotko, E. W., Federmeier, K. D., & Kutas, M. (2012). To predict or not to predict: Age-related differences in the use of sentential context. *Psychology and Aging*, 27, 975–988. doi:10.1037/a0029206
- Zurif, E., Swinney, D., Prather, P., Wingfield, A., & Brownell, H. (1995). The allocation of memory resources during sentence comprehension: Evidence from the elderly. *Journal of Psycholinguistic Research*, 24, 165–182. doi:10.1007/BF02145354



## The role of cognition on age-related changes in language, memory, and mental models

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Many studies have shown that as people age, they tend to show deficits in cognitive abilities (e.g., Salthouse, 2012). However, the goal of cognitive aging research is to not only examine these deficits, but also to examine what abilities are maintained (e.g., Stine-Morrow, Miller, Gagne, & Hertzog, 2008). For example, cognitive studies of language processing have shown that older adults, relative to younger adults, place a greater emphasis on memory for the major ideas that were expressed, even though they tend to have difficulty remembering the exact wording that was used (e.g., Radvansky & Dijkstra, 2007). The goal of this chapter is to provide an overview of how cognitive aging affects language and memory. Specifically, this chapter focuses on how the normal aging process affects both language processing and comprehension with an emphasis on the use of mental models, specifically situation (Zwaan & Radvansky, 1998) or event (Radvansky & Zacks, 2011) models. Because memory is such an important component of language use, this chapter also examines how deficits in memory that are due to normal aging, such as a decline in working memory capacity, can influence how older adults process and comprehend language (e.g., Copeland & Radvansky, 2007).

Over the years, numerous studies have shown that older adults (in a typical cognitive aging experiment, older adults range in age from 60 to 80 years) demonstrate cognitive declines for a number of factors (see Salthouse, 2012 for a review). For example, older adults, relative to younger adults (e.g., 18 to 30 years old), tend to have slower mental processing speed (e.g., Salthouse, 1996), smaller working memory spans (e.g., Salthouse & Babcock, 1991), decreased ability to inhibit irrelevant thoughts (e.g., Hasher, Stoltzfus, Zacks, & Rypma, 1991), diminished reasoning ability (e.g., Fisk & Sharp, 2002; Gilinsky & Judd, 1994), and poorer

performance on tests of long-term memory (e.g., Dijkstra & Misirlisoy, 2009). These declines are thought to be a part of the normal aging process in healthy older adults. However, despite these deficits, there is also evidence that older adults retain important cognitive processing. One aspect of cognitive processing that is retained by older adults is the construction and reliance on mental models (Johnson-Laird, 1983); specifically, situation (Zwaan & Radvansky, 1998) or event (Radvansky & Zacks, 2011) models. These terms will be defined in more detail in a later section, but for now, generally, they are mental representations of an event that is either experienced or derived from language (e.g., a narrative). The focus of this chapter is on older adults' performance on language and memory tasks that involve the use of situation or event models. After an introduction to these types of memory representations, this chapter explores older adults' performance in the area of text comprehension, drawing inferences, integrating information, and event segmentation. In addition, this chapter also includes discussion of how factors such as working memory and inhibition can influence older adults' long-term retention of information.

### **Factors that affect older adults' language comprehension**

Throughout this chapter, there is discussion of significant research that demonstrates that older adults retain some cognitive abilities related to language processing, particularly in the use and reliance on mental models. However, as stated in the opening, older adults also clearly show deficits in cognitive performance. Two major factors that have been linked to older adults' deficiencies in language comprehension are working memory and inhibitory ability (Borella, Ghisletta, & de Ribaupierre, 2011). These two constructs have been shown to decline during the normal aging process, and a number of studies have established how these declines are related to performance on language tasks. Before discussing the research related to aging and situation or event model use, the following sections first provide a brief overview of working memory and inhibition deficits for older adults.

#### **Working memory**

Regardless of whether one applies the multi-component view of working memory (e.g., Baddeley, 2001) or a perspective that focuses on the attentional component of working memory (e.g., Unsworth & Engle, 2007), working memory capacity, as measured by span tests (Conway et al., 2005), is thought to be related to language comprehension. This is because most, if not all, theories of working memory

capacity regard it as the ability to manage multiple pieces of information. This can include the active maintenance of information that needs to be integrated with later information (e.g., Copeland & Radvansky, 2007), constructing or accessing a mental image while reading (e.g., Madden & Dijkstra, 2010), or constructing multiple representations that are related to one another (e.g., Copeland & Radvansky, 2004).

While working memory appears to be involved in various aspects of language comprehension, it should be noted that working memory span does not always relate to situation model performance (Radvansky & Copeland, 2004, 2006). Instead, it seems to more directly relate to the surface and textbase levels of representation. That is, a typical verbal-based span task (e.g., reading span, operation span, etc.) requires people to maintain representations of words or letters that were presented; however, these tasks do not require people to process or represent what the text was about (although, see Radvansky & Copeland, 2004 for a situation memory test). Studies have clearly shown that older adults, relative to younger adults, have much lower working memory span scores (Salthouse & Babcock, 1991) and, as we discuss later in the chapter, this may be connected to older adults' deficits at certain levels of memory (e.g., surface and textbase levels of memory – these are described in more detail in a later section of this chapter). Also, working memory capacity has been shown to be related to accuracy when younger and older adults were asked to recall text content (Stine-Morrow, Shake, Miles, & Noh, 2006). However, it is important to note that declines in performance for older adults are more likely to occur when the scenario becomes more complex, such as when there are more entities or chunks to maintain in working memory (e.g., Gilchrist, Cowan, & Naveh-Benjamin, 2008) or when inhibition is required because prior information can potentially interfere with information that is currently being processed (e.g., Hasher & Zacks, 1988).

## Inhibition

Inhibition, which is a reduced ability to suppress irrelevant information, underlies age-related declines in memory, including deficits related to language processing. Hasher and Zacks (1988) have proposed an aging and inhibition hypothesis of age-related memory impairments based on reduced inhibitory attentional mechanisms. Specifically, they have proposed that the inhibitory attentional mechanisms, which suppress irrelevant information from being active in working memory, become inefficient with aging. The primary consequence of reduced inhibitory attentional mechanisms is an increased difficulty regulating the information in working memory, which results in older adults having trouble inhibiting

irrelevant or competing information (Gerard, Zacks, Hasher, & Radvansky, 1991; Hasher & Zacks, 1988). Support for this inhibitory hypothesis has come from interference studies demonstrating that older adults maintain access to information even after it is no longer relevant, leading to retrieval competition between current/relevant information and prior/irrelevant information (e.g., Hamm & Hasher, 1992; Hasher, Zacks, & May, 1999; May & Hasher, 1998).

Recent research conducted by Healey and colleagues has examined the notion that the inability to suppress irrelevant or competing memories is why older adults have trouble resolving interference. A study by Healey, Hasher, and Campbell (2013) investigated older adults' memory for ideas competing for attention and found that older adults named competitors more quickly than younger adults, suggesting that older adults have a suppression impairment making competitors more accessible to them. Additionally, Healey, Ngo, and Hasher (2013) examined suppression of competitors during interference resolution and found that younger adults suppress competing information during interference resolution; also, greater memory performance was associated with stronger suppression for the younger adults. For the older adults, however, they found no evidence of suppression of competing information. Together, these findings support an inhibitory theory and the idea that age-related memory deficits can be due to both encoding and retrieval disruption caused by reduced ability to suppress information. While these studies do not directly demonstrate that inhibitory deficits affect language or text processing, later in this chapter we will review other studies that suggest that this deficit inhibiting information for older adults can have implications for their performance on a variety of tasks, including but not limited to discourse processing, integrating information, reasoning, and drawing inferences.

### **Situation models and event models**

Event models fall under the broad category of mental models (Johnson-Laird, 1983; van Dijk & Kintsch, 1983), which include mental representations of events, experiences, and systems. While a mental model can include representations that are not experiential (e.g., knowledge of how something works), an event model is specifically a mental representation of an event. An event can either be directly experienced (i.e., an experience model), such as witnessing other people interacting, or it can be linguistically-based (i.e., a situation model), such as reading a narrative (Zwaan & Radvansky, 1998). Event models are important because so much of people's lives can be classified as events, and people's memories of reading about story characters' experiences (e.g., when reading a novel) share

a lot of similarities with their own autobiographical memories (e.g., Copeland, Radvansky, & Goodwin, 2009; Radvansky, Copeland, & Zwaan, 2005); this includes the chronological representation of events and the likelihood of recalling certain events.

Situation models are a specific type of event model that are based on language and go beyond the words that are used; that is, situation models represent what is described and the message being communicated when people use language. As an overview, when people read or hear language, they typically construct three different levels of memory representation (Radvansky, Zwaan, Curiel, & Copeland, 2001). The first level is the surface representation and it consists of one's memory for the words that were actually used. This level of memory representation is typically not important unless someone needs to retain the exact information (e.g., memorizing definitions verbatim for a test), or the exact wording is crucial for conveying the appropriate meaning (e.g., the punch-line of a joke).

The second level of representation is the propositional textbase, which consists of the ideas conveyed in language, but not necessarily in the exact words that were used. For example, for the utterance, "The doctor prepared the shot and the patient became tense," the textbase representation could be, "The patient became tense as the doctor readied the shot." In this example, the same information is being conveyed in both sentences; however, the exact wording is not retained. Relative to the surface level, the textbase representation tends to be more important because it contains the basic ideas that were expressed, which can be important when trying to learn new information when there is no need to retain the exact wording (e.g., learning the general meaning of a concept without needing to memorize the exact wording of its definition).

The third level includes situation models, which are thought to be the highest of these levels of memory representation (Zwaan & Radvansky, 1998). Situation models not only represent the ideas that were expressed, but they also include inferences and the integration of related information. For the example above, the situation model may contain typical inferences, based on schemas or scripts, such as, "The doctor and patient are in a hospital," or "The patient is tense because he is afraid of needles." In addition, people can also elaborate on the information based on their own experiences or biases. In this case, they may use personal experiences to fill in missing information, such as representing the doctor as a brown-haired woman if their own doctor is a brown-haired woman. Situation models are important because they contain a fuller representation of what was described, allow people to alter and integrate information so that it is better organized, and can include inferences when ideas are not explicitly stated.

## Aging and the use of situation models during text comprehension

Early evidence for the idea that people construct situation model representations from text came from a study by Bransford, Barclay, and Franks (1972). In this study, people were presented with sentences and were later given a recognition test. The key manipulation was that, on the recognition test, people were presented with the original sentences and altered versions of those sentences that were identical except for the change of one word. For example, people may have been presented with either this sentence “Three turtles rested on a floating log and a fish swam beneath *them*,” followed by this altered version, “Three turtles rested on a floating log and a fish swam beneath *it*.” A second example of an original and altered sentence were, “Three turtles rested beside a floating log and a fish swam beneath *them*,” and “Three turtles rested beside a floating log and a fish swam beneath *it*,” respectively. The first pair of sentences (“rested on”) was easily confused, but the second pair of sentences (“rested beside”) was not; the reason is that the first pair refers to the same situation (i.e., the fish swim beneath both the turtles and the log) while the second pair refers to different situations (i.e., the fish either swims beneath the turtles or the log). Because there was only one word changed from the original to the altered sentence in each pair, this supports the idea that people were relying on a situation model and not the exact words (or surface level representation) that were presented. Radvansky, Gerard, Zacks, and Hasher (1990) examined this effect in the context of aging and they showed that older adults performed similar to younger adults, in that both groups were more likely to confuse sentences that referred to the same situation model. This suggests that older adults maintain the ability to construct and use situation models from text.

Some recent studies have examined the possibility of using mental images during text comprehension. A study with younger adults suggested that they construct or activate mental images during a language comprehension task (Madden & Zwaan, 2006). In an aging study, Dijkstra, Yaxley, Madden, and Zwaan (2004) asked younger and older adults to read sentences followed by a picture recognition task (see Madden & Dijkstra, 2010 for a similar study using a picture naming task). In this task, the key manipulation was whether the picture matched in shape to the text description (e.g., an eagle flying with wings spread vs. an eagle sitting perched in a nest with its wings tight). The idea here is that if people construct an image during language comprehension, then there should be facilitation (i.e., faster response times) when the sentence and image (presented later) match. While both groups showed facilitation for the matching pictures, the effect was larger for older adults, suggesting that older adults were constructing a richer situation model representation that included a visual image that matched what was read in the text.

Other studies have looked to gather more evidence for the reliance on different levels of memory representation. In a study by Radvansky et al. (2001), younger and older adults were presented with narratives followed by a recognition test. The test used here was based on a procedure developed by Schmalhofer and Glavanov (1986) to examine the extent to which people rely on the surface, textbase, and situation model levels in memory. People's ability to distinguish verbatim sentences from paraphrased items (i.e., same idea as the verbatim sentence, but with slight wording changes) reflected the surface level, the ability to distinguish paraphrased items from inference items (i.e., ideas consistent with the text, but not explicitly stated in the text) reflected the textbase level, and the ability to distinguish inference items from incorrect items (i.e., ideas inconsistent with the text) reflected the situation model level. The results clearly showed that while younger adults had better memory for the surface and textbase levels of representation, older adults showed a reliance on the situation model level that was greater or equal to the younger adults. This finding was later replicated by Radvansky, Copeland, and Zwaan (2003) with a brand new set of materials.

These findings are consistent with a set of studies conducted by Stine-Morrow and colleagues (Shake, Noh, & Stine-Morrow, 2009; Stine-Morrow, Gagne, Morrow, & DeWall, 2004). The study by Stine-Morrow et al. (2004) used reading times to examine the extent to which older and younger adults allocate attention to the textbase and situation model levels. A key finding was that during the initial reading of the texts, older adults clearly allocated more attention to the situation model than younger adults.<sup>1</sup> In a more recent study, Shake et al. (2009) explored these age differences even further by presenting younger and older adults with facts or elaborated text, which encouraged either textbase or situation model processing, respectively. Their findings showed superior performance by the younger adults for learning simple facts (i.e., which encouraged textbase processing) whereas older adults' performance was greatly improved when presented with the elaborated texts (i.e., which encouraged situation model processing). While it may intuitively seem like elaborated texts could be more taxing on working memory, and hence, lead to worse performance for the older adults, a key idea to remember is that a rich, integrated, representation is not as taxing on working memory as maintaining separate pieces of information (that are not integrated). As an example, people can remember a more elaborated set of numbers that are chunked (e.g., a ten digit telephone number) better than a list of ten separate digits that are not chunked. Here, the individual digits are simple, but because they

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1. It is important to note that it is unclear whether older adults allocate more attention to the situation model (and less to the textbase) because they are aware of the importance of situation models or whether it is a result of changes due to cognitive aging.

are stored separately, they are not retained as well as the digits that are integrated into a more elaborate representation that includes knowledge that it is a telephone number.

### Situation model dimensions

Another way to examine situation model processing is to break them down into various dimensions. According to Zwaan and Radvansky (1998), situation models are based on a number of key dimensions: space, time, entities, causality, and goals. First, situation models are based on a spatial framework, or location. Space can also include information about where people or objects are relative to each other, such as, "The sink is to the left of the door." Time can deal with the actual time point when an event occurs (e.g., "The disaster happened yesterday") as well as with the sequence or timeline of events (e.g., "I took a nap before dinner"). Entities simply refer to people or objects (e.g., a character in a story). Causality deals with the question of "why did that happen?" and involves cause and effect relationships (e.g., "He sat because he was very tired"). Finally, goals refer to the intentions that people have to accomplish a task, such as wanting to move to another location or to purchase a specific object.

Some studies have examined all of these dimensions together, and these studies typically involve an event-indexing analysis using reading times of sentences or phrases (e.g., Zwaan, Magliano, & Graesser, 1995). In this analysis, a line of text (e.g., a sentence or phrase) is first coded as a zero or one to indicate whether each dimension shifted in that sentence or phrase. For example, if the story changed locations, then that would be coded as a spatial shift; if there was a jump in time to the past or future, then that would be coded as a time shift. The idea is that if people monitor and update their situation models based on these dimensions, and that this updating process takes time, then there should be longer reading times when these situational shifts occur. While Zwaan et al. (1995) initially demonstrated that these patterns are observed when younger adults read passages of text, Radvansky et al. (2001) examined this idea with both younger and older adults and found that these groups monitor situational shifts similarly. When presented with narratives, both younger and older adults had slower reading times when there were shifts in space, time, entities, causality, and goals.

A number of aging studies have also been conducted to examine these situation model dimensions separately, and most of these studies show similar performance for younger and older adults (Radvansky & Dijkstra, 2007). For example, older and younger adults show similar processing of spatial information while reading a text, in that both groups accessed information about objects

more quickly when the objects were closer to the protagonist's location in a story (Stine-Morrow, Morrow, & Leno, 2002). That is, both age groups were faster to access objects that were in the same room as the protagonist than if the objects were in a different room. In addition, older and younger adults both access earlier information from a narrative more slowly following a long time shift, suggesting that both age groups use a time shift as a cue that the situation is changing and that they need to construct a new situation model (Radvansky, Copeland, Berish, & Dijkstra, 2003). Finally, Radvansky and Curiel (1998) demonstrated that older adults represent and update goal information in a similar manner to younger adults. Specifically, both age groups keep current/uncompleted goals more accessible than goals that have been completed.

While those studies show similar patterns of performance for older and younger adults, a recent study by Noh and Stine-Morrow (2009) showed a clear deficit for older adults when examining the entity dimension. In this study, people were presented with short narratives that varied in terms of the introduction of new characters. Relative to the younger adults, older adults had more difficulty accessing information about an earlier character after the introduction of a new character, and they also had difficulty encoding information about a new character when other characters were present in the current situation of the story. Noh and Stine-Morrow interpreted this to be due to a reduced working memory capacity for the older adults, suggesting that some aspects of situation model processing can be negatively affected by deficits in working memory if the situation becomes complex enough or difficult to integrate the information.

To summarize the studies described in this section, while there are some exceptions (e.g., Noh & Stine-Morrow, 2009), a number of studies suggest that older adults are capable of constructing and using situation model representations while comprehending language. In fact, the evidence suggests that they seem to focus on this level of representation as much as, and sometimes more than, younger adults (e.g., Radvansky et al., 2001). It should be noted that this does not mean that younger adults are poorer at constructing and utilizing situation models. For example, in the Radvansky et al. (2001) study, the dependent measurement is an indicator of how much a person is currently relying on a particular level of representation; that is, it is not necessarily a measure of the strength of the situation model. When a memory test is given shortly after reading, while younger adults show greater reliance on the surface and textbase levels than older adults, this does not mean that younger adults do not construct situation models. For this immediate memory task, the younger adults are relying on their more detailed surface and textbase representations. If the same test is administered after a delay (e.g., two days), then younger adults' surface and textbase memories decline by that point and their reliance on situation models increases (Radvansky et al.,

2001). Thus, some tasks or measures used in studies allow for younger adults to rely more on surface and textbase levels of memory, which can mask the strength of their situation model representation. The clear take away message here is that, while older adults show deficits at the surface and textbase levels, they retain the ability to construct and access situation models in memory.

## Activating and inhibiting inferences

### Drawing inferences

Thus far, research has shown that older adults maintain an ability to use situation models during text comprehension tasks. Additional studies have examined specific types of inferences that are made during narrative comprehension. For example, a recent study by McKoon and Ratcliff (2013) suggests that older adults make predictive inferences<sup>2</sup> while reading text similarly to younger adults, and another study by McGinnis, Goss, Tessmer, and Zelinski (2008) showed that the number of inferences drawn by younger and older adults to also be similar, even when including a group of older adults above the age of 75. Also, older adults are just as likely as younger adults to believe inferences that were later shown to be incorrect (Guillory & Geraci, 2010).

Other studies have considered the extent to which older adults process the deeper meaning of a text. In one study, Adams, Smith, Nyquist, and Perlmutter (1997) had younger and older adults read narratives followed by a test that either asked them to recall the text as accurately as possible or to provide an interpretation of the story. While younger adults were better at recalling the text in a literal manner, older adults were more likely to interpret the text in a deep, synthesized way; the former reflects memory of the surface and textbase levels, while the latter reflects not just the situation model level, but also the fact that they made inferences by synthesizing aspects of the narrative. This finding is consistent with a study conducted by Narvaez, Radvansky, Lynchard, and Copeland (2011) that examined the extent to which people draw moral inferences from stories. In this study, older adults remembered what was stated in the text better if the information was related to morality (i.e., their performance in this condition was similar

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2. It may be helpful to clarify that predictive inferences are different than making language predictions. The former involves using context to anticipate what type of events may happen next. The latter refers to predicting what word might come next in a sentence; research with event related potentials (ERPs) has shown that older adults perform more poorly than younger adults in making language predictions (e.g., Federmeier, Kutas, & Schul, 2010).

to that for younger adults). In addition, using a lexical-decision task, this study showed that older adults were more likely than younger adults to draw moral inferences as they read. In this study, the lexical-decision task was able to assess the use of situation models because the lexical decision probes consisted of words that were consistent with inferences. That is, the lexical decision probes were not based on information directly stated in the text, instead they were based on ideas that would likely be activated and incorporated into a situation model if people were actively drawing moral inferences while reading. One possible reason for the age differences in terms of drawing moral inferences is that the younger adults may have initially drawn these inferences, but then thought that these moral inferences were irrelevant, leading them to suppress these inferences. In contrast, the older adults, with declining inhibitory skills, may not have suppressed them. It should be noted, though, that this is only speculation at this point as there is no converging evidence for this idea (however, see the discussion of stereotypes and suppression later in this section for possible parallels).

## Emotions

Another area that has been examined is the processing of emotion information. While there is some evidence that younger and older adults are similar in terms of activating emotion information while reading (e.g., Soederberg & Stine, 1995), other studies have shown that older and younger adults tend to focus on information differently based on emotion. Carstensen and Turk-Charles (1994) showed that older adults, relative to younger adults, recalled more emotional than neutral material from a narrative. One possibility for seeing slightly different patterns in these studies is that in the latter study, participants were instructed to try and identify with one of the characters (this is not a typical instruction in studies of narrative comprehension). It is possible that the older adults better identified with the story characters (because of more life experiences, they may have better related to the adult characters), which may have led to better memory for emotional content.

Other research dealing with emotion and aging suggests that older adults tend to focus more on positive information (i.e., the positivity effect) and recall less about negative stimuli (Carstensen & Mikels, 2005). This focus on positive emotions appears to be a result of perspective-taking by older adults. For example, Sullivan, Mikels, and Carstensen (2010) asked older and younger adults to read narratives that included older and younger characters. When asked to recall information from the perspective of those characters, older adults' recall was more positive for the older characters and more negative for the younger characters,

whereas the younger adults did not show a difference in emotional information recalled when taking the perspective of the different aged characters. Further support for this was shown using an implicit lexical-decision task, where older adults responded more quickly to positive items during the basic task, but responded more quickly to negative items after adopting the perspective of a young adult (Lynchard & Radvansky, 2012).

### Incorrect inferences and stereotypes

Other studies of inference making by older adults has considered the influence of declining inhibitory skills. Hamm and Hasher (1992) showed that older adults are more likely to maintain activation of a competing, but incorrect, inference longer than younger adults, possibly because of an inability to suppress competing ideas. The exploration of the effects of older adults' deficiencies in inhibition was also considered in the context of stereotype inference-making (e.g., von Hippel, Silver, & Lynch, 2000). In that study, older adults had difficulty suppressing background information about two individuals when making judgments about later information. Importantly, inhibitory ability was an important mediator of the age effects (i.e., older adults relying on the background information) while prejudice was not. Consistent with this finding, Overman, Wiseman, Allison, and Stephens (2013) showed that older adults' knowledge of earlier background information, based on someone having a good or bad childhood, affected their memory for details of a crime that were presented later.

Radvansky, Copeland, and von Hippel (2010) used a narrative comprehension task to examine stereotype inference-making. Here, younger and older adults, who did not differ in their desire to not be prejudiced,<sup>3</sup> were presented with narratives that allowed for stereotype inferences. On a memory test following reading, older adults showed a greater likelihood of relying on inferences, both for neutral and stereotype stimuli. In addition, a lexical-decision task was also used to assess inference making while reading each narrative. As expected, both younger and older adults showed facilitation for neutral (i.e., non-stereotype) inferences (based on story context) presented as lexical-decision probes, suggesting that

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3. Attempts were made to equate the age groups on their desire to not be prejudiced, as measured by the Attitudes Towards Blacks Scale (Brigham, 1993) and the Internal and External Motivation to be Non-Prejudiced Scales (Plant & Devine, 1998). This is important because it can reduce the possibility that any age group differences are due to cohort differences (e.g., that older adults may have been raised in a time when stereotype expression was more acceptable) and increase the likelihood that the older adults included in the study would try to suppress negative stereotypes that were activated in their memory.

both groups were drawing inferences as they read. But, importantly, the younger adults showed a clear effect of suppression for the stereotype inferences presented as lexical-decision probes. In contrast, the older adults showed no evidence of suppression; if anything, the older adults' data suggested that there may have been some facilitation for these stereotype inferences. These results suggest that both age groups were drawing and maintaining neutral inferences as they read, but for the stereotype inferences, while the younger adults were successfully able to suppress them, the older adults were not (even though they were equal to the younger adults on their desire not to be prejudiced). These interpretations were supported by research (Gonsalkorale, Sherman, & Klauer, 2009) using multinomial modeling along with an implicit association task that found more support for an inhibition deficit explanation than an explanation based on cohort differences (i.e., older adults grew up in a less tolerant environment).

Together, these studies show that older adults retain an ability to draw inferences from text. In some cases, older adults seem to make more inferences than younger adults, especially when it comes to deep processing of the text. Related to this, while older adults demonstrate this ability to draw inferences, not all inferences are relevant, and some inferences are not desirable, such as stereotypes. The evidence suggests that older adults have difficulty suppressing these stereotypes after they are made, which is consistent with the idea that older adults have declining inhibitory skills relative to younger adults. Thus, both age groups may draw inferences while reading and constructing situation models, but only younger adults, with intact inhibitory skills, are able to suppress irrelevant or undesirable inferences.

## **Integrating and reasoning about information in memory**

### **Text integration**

In addition to the research with narratives that was described above, other studies have examined how well older adults integrate simple facts in long-term memory. For example, information that needs to be learned is not necessarily presented with ample context that includes a well-described spatial-temporal framework or information about causal relations. One area in which this has been studied is with research related to the idea of the fan effect (Anderson, 1974). The fan effect is a finding in cognitive psychology that when there are more facts associated with a single construct, people tend to show signs of interference during retrieval. That is, when asked to retrieve any one fact from memory, the other related facts may interfere with this process and lead to slowdowns in retrieval and/or

errors in performance. This idea is best illustrated with an example. Consider the following sentences: “The computer is in the office,” “The computer is in the laboratory,” and “The computer is in the library.” If asked to verify any one of those facts about the computer, people are slower to respond and make more errors than if they only learned one of those facts or if they had learned three completely unrelated facts (i.e., that three different objects, such as the computer, television, and camera, are in three different locations). Research by Radvansky and others (Gerard et al., 1991; Radvansky, Zacks, & Hasher, 1996) has demonstrated that both younger and older adults are susceptible to the fan effect, demonstrating similar patterns of slowing down and making more errors as the number of related concepts increases.

What is interesting, however, is that Radvansky and colleagues (Gerard et al., 1991; Radvansky et al., 1996) have also shown that the fan effect does not always occur, even when facts have overlapping constructs. For example, consider the following sentences: “The bookshelf is in the bedroom,” “The poster is in the bedroom,” and “The cell phone is in the bedroom.” Here, as in the previous example, there are three facts with an overlapping construct; in the first example it was the computer, here it is the bedroom. However, with this set of facts, a fan effect is not observed. The reason for the difference is that, when learning the facts, people construct integrated situation models of the information. In the first example, for the facts related to the computer, the three facts refer to different locations, and because spatial locations typically form the foundation of a situation model, people are likely to construct three separate situation models (one for each location). In the second example, for the facts related to the bedroom, the three facts all pertain to the same spatial location, so people can construct a single, integrated situation model about the bedroom that includes all of the facts. While both younger and older adults showed patterns of retrieval interference with items like those in the first example, neither younger nor older adults showed effects of interference when the facts could all be integrated into a single model (Gerard et al., 1991; Radvansky et al., 1996).

Building on this even further, Radvansky, Zacks, and Hasher (2005) explored whether younger and older adults showed evidence of using inhibition to manage retrieval interference during a fan effect task. Consider the scenario when there is a fan effect; that is, when facts have an overlapping construct but cannot be easily integrated. When one of the specific facts is presented in a recognition task, not only is that fact likely to be activated in memory, but the other related facts may act as competitor items for one’s attention (because of the overlapping construct related to all of the facts). To manage that interference, people may attempt to inhibit the competing facts. To illustrate this idea, consider the computer example again. If presented with a true/false recognition item of “The computer is in the

office,” the other related facts of “The computer is in the laboratory” and “The computer is in the library” may compete for activation because they all share the construct of “computer.” To alleviate the interference, people should suppress the latter two items in memory. The result of this is that on a trial that immediately follows, people should be slower than usual to recognize one of these latter facts because they were suppressed on the original trial.

Consistent with the inhibition research that was discussed in an earlier section (Hasher & Zacks, 1988), younger adults showed evidence of suppression, but the older adults did not (Radvansky, Zacks, & Hasher, 2005). This suggests that older adults, due to deficiencies with inhibition, have more difficulty managing the interference in a fan effect task. However, as described in this section, older adults clearly maintain the ability to integrate multiple, related facts into a single situation model (Gerard et al., 1991; Radvansky et al., 1996).

## Reasoning

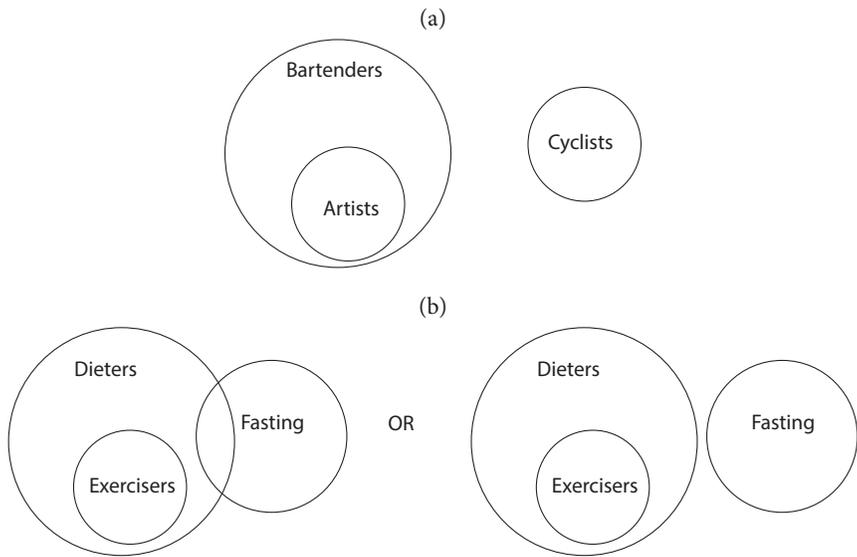
The effects of aging on the use of integrating information into situation or event models have also been examined in the context of reasoning tasks. Studies have examined the performance of older adults, relative to younger adults, using syllogistic reasoning (e.g., Gilinsky & Judd, 1994), belief bias (e.g., De Neys & Van Gelder, 2009), and integration tasks (e.g., Copeland & Radvansky, 2007). In general, older adults tend to show deficits in performance for all of these tasks, but closer inspection reveals some interesting patterns in their performance, including evidence that older adults continue to use, or attempt to use, integrated mental representations.

A typical syllogistic reasoning task consists of presenting people with linguistic statements that describe the categorical relations between three objects; that is, people are presented with two statements that describe a situation involving three objects. At that point, they must either come up with a conclusion that logically follows (if there is one; some syllogisms have no valid conclusion) or evaluate whether a presented conclusion is true or false. For example, a syllogism could consist of statements such as, “All of the artists are bartenders, and none of the bartenders are cyclists,” or “Some of the dieters are exercisers, and none of the exercisers are fasting.” In the first example, the logical conclusion is that “None of the artists are cyclists,” because if every single artist is a bartender, and none of them are cyclists, it must follow that no artists are cyclists either (see Figure 1a). For the second example, it might be tempting to conclude that “Some of the dieters are fasting,” however, it is not clear if this is definitively true. The only thing

that one can conclude with certainty is that “Some of the dieters are not fasting,” because those dieters that are exercisers cannot be fasting (see Figure 1b).

While there are many different theoretical explanations of syllogistic reasoning that have been proposed over the years (Khemlani & Johnson-Laird, 2012), one idea is that people can rely on two different systems during the reasoning process (e.g., De Neys, 2006; Evans, 2003). According to this view, people have an automatic system that can be based on heuristic processing or prior knowledge, and another system that includes deliberate processing, reasoning, and representation of entities (see Kahneman, 2011, for a discussion of what he labels system 1 and system 2, respectively). The former system leads to quicker responses and is thought to be minimally taxing on working memory. In contrast, the latter system can consist of the application of logical rules, if someone has training in that domain, or possibly the construction of situation model representations, both of which are more taxing on working memory and take longer to construct (Johnson-Laird, 2006).

In two separate studies, Gilinsky and Judd (1994) and Fisk and Sharp (2002) examined aging effects by having younger and older adults solve syllogisms that either required the use of one model or multiple models. One model syllogisms are simple syllogisms in which there is only one possible conclusion that can be drawn if someone constructs an accurate model; the “artists-bartenders-cyclists” example above is an example of a one model syllogism (see Figure 1a). In contrast, a multiple model syllogism is more difficult because different models can be constructed, and one must determine the conclusion that is true for all of those representations (the “dieters-exercisers-fasting” example above; see Figure 1b). Overall, the younger adults consistently outperformed the older adults for both types of syllogisms; Gilinsky and Judd (1994) observed larger age effects for the multiple model syllogisms, but Fisk and Sharp (2002) did not observe a larger effect for multiple model syllogisms. Both studies show that older adults can construct a single model and do well when there is little complexity, but older adults’ performance may drop off when multiple representations must be constructed and managed, likely due to the increased burden on working memory. This drop-off is attributed to working memory declines because working memory capacity has been correlated with syllogistic reasoning performance (Copeland & Radvansky, 2004), particularly for syllogisms requiring the use of multiple models (with which the older adults have more difficulty). That is, single model syllogisms are quite simple, and do not tax working memory very much; hence, younger and older adults both do well on these problems. In contrast, multiple model syllogisms require people to construct and maintain more than one representation in memory, which is taxing on the working memory system. Because older adults have smaller working memory capacities, they tend to have difficulty with multiple model syllogisms.



**Figure 1.** Euler circle representations of the possible representations of the described syllogisms: (a) “All of the artists are bartenders, and none of the bartenders are cyclists,” and (b) “Some of the dieters are exercisers, and none of the exercisers are fasting.” In (a) it is clear that “none of the artists are cyclists”. In (b) it might be tempting to conclude that “some of the dieters are fasting”, but only “some of the dieters are not fasting” is true in all representations.

Other researchers have examined older adults’ syllogistic reasoning performance by modifying the materials to examine the belief bias effect (e.g., De Neys & Van Gelder, 2009). The belief bias effect refers to the finding that, when evaluating the logical validity of a presented conclusion, people tend to be more likely to accept a non-logical conclusion when the conclusion statement fits with one’s prior knowledge or beliefs. For example, in the second example from earlier, the incorrect conclusion that “Some dieters are fasting,” is likely to be consistent with people’s prior experiences with people and diets, and thus, people may be tempted to accept that conclusion as logically true, when in reality, “some dieters are not fasting” is the only conclusion that logically follows based on the information in the premises.

According to De Neys and Van Gelder (2009), these tasks not only tap the ability to reason, but also the ability to inhibit. For example, when belief and logic conflict (i.e., conclusions that are logical but unbelievable, or conclusions that are illogical but believable), people must first inhibit their fast, belief-based system (i.e., system 1), and then those people must engage their more deliberate reasoning processes (i.e., system 2). In their study, consistent with observations made by

Gilinsky and Judd (1994), there were no age effects when belief and logic did not conflict (i.e., conclusions that were both logical and believable, and conclusions that were both illogical and not believable); here, people could use either system to reach these conclusions, and because of that both age groups did well on these type of syllogisms. In contrast, there was an age effect when there was a logic-belief conflict, suggesting that older adults had difficulty inhibiting the belief system and engaging in the reasoning process. Consistent with this interpretation, Tsujii, Okada, and Watanabe (2010) used near-infrared spectroscopy to examine inferior frontal cortex activation during this logic-belief conflict task. After replicating the behavioral pattern observed by De Neys and Van Gelder (2009), they examined brain activation patterns when participants were accurate (i.e., they used inhibition to overcome the belief bias effect). Their analyses showed that accuracy for the older adults was related to inferior frontal cortex activation in both hemispheres, whereas for the younger adults, accuracy was only related to activation in the right hemisphere. Tsujii et al. (2010) interpreted this to mean that older adults, when accurate (i.e., when successfully using inhibition to avoid accepting the believable conclusion), needed to use both hemispheres to overcome their deficits in inhibitory abilities (relative to the younger adults).

The role of working memory capacity in aging effects for reasoning tasks has also been considered in a number of studies. In particular, these studies examined older adults' ability to integrate multiple pieces of information. When presented with relational information auditorily, such as "Andy is taller than Bill," "Bill is taller than Chad," and "Chad is taller than Dan" (i.e., an AB-BC-CD overlapping sequence), older adults have difficulty when the relations are presented in a non-overlapping sequence (e.g., AB-CD-BC). This suggests that older adults have difficulty maintaining the information in working memory until the appropriate information is eventually presented that allows for integration (Light, Zelinski, & Moore, 1982). The fact that these difficulties are due to deficits with integration in working memory was further supported by the fact that the older adults in Light et al.'s (1982) study were more accurate in identifying presented items than inferences (i.e., in this task, inferences depend on integration).

A similar deficit for integration was observed for older adults in a task in which people were visually presented with these types of relations, especially when the level of complexity increased (Viskontas, Holyoak, & Knowlton, 2005). A study by Copeland and Radvansky (2007) examined integration in task involving sentences that conveyed spatial relations, such as "The apple is above the blueberry," "The blueberry is to the left of the carrot," and "The carrot is below the date." In this study, older adults had a great deal of difficulty integrating the spatial relations into a single spatial layout, particularly when they were presented in a non-overlapping sequence. This was true even when, instead of sentences, words

- (a) “The apple is above the blueberry.”  
APPLE  
BLUEBERRY
- (b) “The blueberry is to the left of the carrot.”  
BLUEBERRY CARROT
- (c) “The carrot is below the date.”  
DATE  
CARROT

**Figure 2.** Examples of the visual depictions of spatial relations (with word stimuli) used by Copeland and Radvansky (2007). In one experiment, participants were presented with only the sentences, one at a time. In another experiment, participants were presented with only the spatial diagrams (without the sentences), one at a time. Finally, in a later experiment, the words in the spatial diagrams were replaced by pictures of those objects.

were presented depicting the spatial relation, as depicted in Figure 2 (e.g., the first sentence was replaced by the word `APPLE` visually depicted above the word `BLUEBERRY`; the second sentence was replaced by the word `BLUEBERRY` visually depicted to the left of the word `CARROT`; finally, the third sentence was replaced by the word `CARROT` visually depicted as below the word `DATE`). Thus, saving them a step in terms of constructing a mental representation by visually presenting the spatial relations of the words, was not enough to improve performance for the older adults. Interestingly, though, performance increased significantly (i.e., both higher accuracy on a final memory test and faster processing during learning) when pictures of the objects in those spatial relations (e.g., the first sentence was conveyed with a picture of an apple above a blueberry) were presented instead of sentences. This suggests that pictures may be easier for older adults to retain in working memory when they need to maintain that information for later integration. These findings are consistent with other recent findings that have shown that older adults benefit greatly from using a map rather than only a verbal description of a route (Meneghetti, Borella, Grasso, & De Beni, 2012).

Together, these studies suggest that older adults are able to represent and integrate information when the situation that is described is not extremely complex. In contrast, when complexity increases, older adults have difficulty managing multiple representations and maintaining information in working memory when it needs to be integrated later. In addition, older adults also show deficits in inhibition which can affect their ability to use more complex reasoning (as opposed to quick decisions based on the belief system). However, despite the deficits in inhibition, working memory, and integration, older adults show evidence of attempting to rely on situation model representations for these tasks. There also appears to

be some evidence that their processing can be aided by the use of images because pictures can be processed more quickly than verbal information.

## Event segmentation

A more recent area of research that has been investigated is the topic of event segmentation. When people mentally represent activities of ongoing events, they organize information into meaningful parts in memory. According to the Event Segmentation Theory (Zacks, Speer, Swallow, Braver, & Reynolds, 2007), people perceive the beginning and end of discrete units of an event, known as event boundaries, and this perceptual process is known to be automatic (Zacks & Swallow, 2007). When people are unable to predict the sequence of a future outcome in an event, they actively update or form connections in working memory to integrate a new event boundary into their event model. This ability to segment event boundaries is important because it allows people to understand and keep track of “what is happening now” in their memory representation (Kurby & Zacks, 2007; Zacks, Kurby, Eisenberg, & Haroutunian, 2011).

Event boundaries can be broken down into a hierarchical structure by identifying them as fine-grained and coarse-grained units (e.g., Zacks & Swallow, 2007). Fine-grained units are the smallest meaningful units that can be seen in event boundaries, whereas coarse-grained units are the largest meaningful units that can be perceived when segmenting the events. To further distinguish these two types of event boundaries, the fine-grained units tend to be enclosed and grouped into coarse-grained units. For instance, in a situation where an individual is baking a birthday cake, the beginning and ending of the entire process can be considered as coarse event boundaries, but the beginning and ending of the acts of adding each separate ingredient (e.g., eggs, flour, sugar, etc.) to make the cake can be considered as fine event boundaries. As outlined below, studies on event segmentation and aging have shown mixed results as to whether older adults tend to focus more on fine-grained or coarse-grained units (see Kurby, Asiala, & Mills, 2013; Kurby & Zacks, 2011).

## Simple and complex events depicted in film

One domain that has been recently used to examine event segmentation is film. Being able to segment meaningful event boundaries can have an important influence on how well people remember events during later retrieval. Two studies (Kurby & Zacks, 2011; Zacks, Speer, Vettel, & Jacoby 2006) had younger and

older adults perform an event segmentation task by having them press a button to determine the event boundaries for movies depicting actors doing everyday activities (e.g., making the bed or washing a car). When examining the fine and coarse event segmentations, the younger adults tended to show more consistent patterns than the older adults (i.e., there was not much variability amongst the younger adults). Although the interpretation of where event boundaries exist in an activity may be subjective, the younger adults tended to agree on similar event boundaries. In contrast, the older adults were less consistent in their segmentations, showing more variability across those participants. Also, because older adults show deficits in the ability to segment simple events that are depicted in film, it can worsen memory for those events (Zacks et al., 2006). One possibility for these deficits is that with film, older adults (who typically demonstrate slower mental processing speed; e.g., Radvansky et al., 2001) may have difficulty keeping up with the pace of a film. In many text comprehension studies, older adults have the opportunity to control the pace by pressing a button to advance to the next sentence in a story, and they typically end up taking longer to read than younger adults (e.g., Radvansky et al., 2001). A second possibility is that these films were depicting very simple events and that stimuli with more elaborated context would allow them to create a richer model-based representation.

In contrast to the results observed when depicting simple events, Kurby, Asiala, and Mills (2013) demonstrated that age groups did not differ as much for segmenting events when richer context was provided for events, such as in a narrative film. In their study, younger and older adults were asked to segment activities occurring in a movie called *The Red Balloon*. They found that when continuous naturalistic activities were connected to narrative context, older adults were able to perform similarly to the younger adults in their event segmentations. These findings are consistent with the second possibility described in the previous paragraph. One reason may be that older adults rely more on their preserved situation models for comprehension (Radvansky et al., 2001); that is, they are able to segment events with the support of a narrative structure. Other reasons may be that with narrative comprehension, older adults use more semantic knowledge, apply more event schemas, and rely on their episodic experiences to understand the story. As was discussed earlier with text comprehension (e.g., Shake et al., 2009), older adults perform better when elaborated text is provided, compared to situations when simple facts are presented. In the case of film, older adults perform better when the film contains rich context, such as a narrative, rather than when depicting simple and unrelated events.

## Pictorial-based narratives

Event comprehension and segmentation has also been examined using text-based and pictorial-based narratives. Although not much research has been conducted in this area with older adults, event segmentations have been observed for children's storybooks. In a study conducted by Magliano, Kopp, McNERney, Radvansky, and Zacks (2012), they compared older and younger adults in their segmentation judgments to a set of either text-only or pictures-only stories. The results showed that while older adults were likely to identify more event boundaries of the stories (i.e., they identified smaller event units) than younger adults, both age groups were able to identify event boundaries for location, time, characters, and goals. However, unlike younger adults, the older adults were less likely to segment based on emotional reactions of characters. At first glance, based on the earlier discussion of text comprehension studies that showed that older adults were as likely as younger adults to monitor and track emotions in narratives (e.g., Soederberg & Stine, 1995), it may seem as though this finding contradicts that earlier work. However, it is important to note that memory for the emotional content was not examined in the Magliano et al. (2012) study; instead, people were simply asked to make segmentation judgments. It is possible that in the Magliano et al. (2012) study, older adults were processing character emotions, but they did not necessarily take that information into consideration when deciding where to segment events.

Overall, this research on event processing using both film and illustrated narratives shows that the segmentation of events does not necessarily decline in age. Importantly, though, older adults perform better when there is adequate context in the form of a narrative. However, without that context, older adults show deficits for event segmentation relative to younger adults. As stated earlier, this is similar to findings with text comprehension that show improved performance by older adults when elaborated context is presented rather than simple facts (e.g., Shake et al., 2009). Finally, because the research on event models is a relatively recent line of research, it has yet to explore possible working memory or inhibition effects related to aging. It will be interesting to see whether future studies show similar parallels to what has been observed with traditional narratives that are presented as text.

## Conclusion

While older adults show clear declines that occur as part of the normal aging process (e.g., Salthouse, 2012), this chapter explored mental model use, where older adults tend to do well. Specifically, the evidence supports the idea that older adults retain the ability to construct and maintain situation and event models. Relative to younger adults, who can better focus on all three levels of representation when comprehending language, older adults tend to focus more exclusively on the situation model level (e.g., Radvansky et al., 2001). Older adults also maintain the ability to draw inferences during comprehension, particularly when there is rich context (e.g., Shake et al., 2009). This is also true for event segmentation; that is, older adults perform similarly to younger adults when narrative context is presented (e.g., Magliano et al., 2012). However, older adults do not always use situation models effectively. Older adults have difficulty when tasks require them to suppress irrelevant or competing information. For example, while older adults draw inferences similarly to younger adults, they are also less able to inhibit unwanted inferences such as stereotypes (e.g., von Hippel et al., 2000). Also, when the information requires multiple representations and must be manipulated, such as in a reasoning task, older adults show deficits in performance, likely due to diminished working memory capacities (e.g., Copeland & Radvansky, 2007).

This line of research, of exploring possible aging effects for mental models, is important, especially in the context of the numerous studies that show cognitive declines. A better understanding of these cognitive processes in which older adults perform well can be beneficial to both theoretical and applied research. In terms of applied research, knowing that older adults can mentally represent and remember information when it is presented with rich context (e.g., as part of a narrative), or that they can perform better when images are used, can affect how materials are created for the older population.

For theoretical research, further examination of older adults' language comprehension can direct research to explore whether specific cognitive skills are maintained as they age (despite limitations in other areas; namely, working memory and inhibition) or whether older adults compensate for those deficits by relying on life experiences or wisdom. For example, in many psychological research studies, younger adults are recruited from college courses, where verbatim memory of text is sometimes encouraged or required; thus, they may be trained to see value in focusing on the surface or textbase levels of representation. Older adults, with more life experiences, may have learned that focusing on the gist and the big picture (i.e., aspects that form the core of situation model representations) is more

important. Another perspective is that older adults' reliance on model representations is not a strategic choice based on life experiences, but is instead a result of an accumulation of cognitive aging deficits. A number of studies provide support for this perspective. For example, in studies of reasoning, older adults have difficulty constructing and manipulating multiple mental models (e.g., Gilinsky & Judd, 1994). Studies of event segmentation have shown that older adults have difficulty segmenting events (e.g., Zacks et al., 2006) unless elaborate context is presented, such as when the film depicts a story (Kurby et al., 2013). Studies of narrative comprehension show that older adults rarely use surface or textbase representations, even when tested shortly after reading (e.g., Radvansky et al., 2001). Because situation and event models, especially for narratives, can be based on a rich contextual set of information as well as schematic knowledge in long-term memory, it might be easier to construct and remember them than it is to represent and remember individual details (that make up a surface or textbase representation). In other words, the reliance on situation or event models might be a result of not being able to construct the other levels of memory representation due to cognitive declines that occur with aging.

At this point, there is not enough evidence to definitively support either perspective; it is possible that the reliance on model representations is based on older adults' strategic approach to tasks, a result of cognitive decline, or it could be some combination of both. However, regardless of which perspective is supported by future research, it is clear that older adults are able to rely on situation models for the most part. It is promising to see that older adults, despite clear cognitive declines in some areas, can continue to function at a high level with important aspects of language comprehension.

## References

- Adams, C., Smith, M. C., Nyquist, L., & Perlmutter, M. (1997). Adult age-group differences in recall for the literal and interpretive meanings of narrative text. *Journal of Gerontology: Psychological Sciences*, 52B, 187–195. doi:10.1093/geronb/52B.4.P187
- Anderson, J. R. (1974). Retrieval of propositional information from long-term memory. *Cognitive Psychology*, 6, 451–474. doi:10.1016/0010-0285(74)90021-8
- Baddeley, A. D. (2001). Is working memory still working? *American Psychologist*, 56, 851–864. doi:10.1037/0003-066X.56.11.851
- Borella, E., Ghisletta, P., & de Ribaupierre, A. (2011). Age differences in text processing: The role of working memory, inhibition, and processing speed. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*, 66, 311–320. doi:10.1093/geronb/gbro02
- Bransford, J. D., Barclay, J. R., & Franks, J. J. (1972). Sentence memory: A constructive versus interpretive approach. *Cognitive Psychology*, 3, 193–209. doi:10.1016/0010-0285(72)90003-5

- Brigham, J. C. (1993). College students' racial attitudes. *Journal of Applied Social Psychology*, 23, 1933–1967. doi:10.1111/j.1559-1816.1993.tb01074.x
- Carstensen, L. L., & Mikels, J. (2005). At the intersection of emotion and cognition: Aging and the positivity effect. *Current Directions in Psychological Science*, 14, 117–121. doi:10.1111/j.0963-7214.2005.00348.x
- Carstensen, L. L., & Turk-Charles, S. (1994). The salience of emotion across the life span. *Psychology and Aging*, 9, 259–264. doi:10.1037/0882-7974.9.2.259
- Conway, A. R. A., Kane, M. J., Bunting, M. F., Hambrick, D. Z., Wilhelm, O., & Engle, R. W. (2005). Working memory span tasks: A methodological review and user's guide. *Psychonomic Bulletin & Review*, 12, 769–786. doi:10.3758/BF03196772
- Copeland, D. E., & Radvansky, G. A. (2004). Working memory and syllogistic reasoning. *Quarterly Journal of Experimental Psychology*, 57, 1437–1457. doi:10.1080/02724980343000846
- Copeland, D. E., & Radvansky, G. A. (2007). Aging and integrating spatial mental models. *Psychology and Aging*, 22, 569–579. doi:10.1037/0882-7974.22.3.569
- Copeland, D. E., Radvansky, G. A., & Goodwin, K. A. (2009). A novel study: Forgetting curves and the reminiscence bump. *Memory*, 17, 323–336. doi:10.1080/09658210902729491
- De Neys, W. (2006). Dual processing in reasoning: Two systems but one reasoner. *Psychological Science*, 17, 428–433. doi:10.1111/j.1467-9280.2006.01723.x
- De Neys, W., & Van Gelder, E. (2009). Logic and belief across the lifespan: The rise and fall of belief inhibition during syllogistic reasoning. *Developmental Science*, 12, 123–130. doi:10.1111/j.1467-7687.2008.00746.x
- Dijkstra, K., & Misirlisoy, M. (2009). Recognition accuracy for original and altered verbal memory reports in older adults. *Quarterly Journal of Experimental Psychology*, 62, 248–256. doi:10.1080/17470210802303693
- Dijkstra, K., Yaxley, R. H., Madden, C. J., & Zwaan, R. A. (2004). The role of age and perceptual symbols in language comprehension. *Psychology and Aging*, 19, 352–356. doi:10.1037/0882-7974.19.2.352
- Evans, J. S. T. (2003). In two minds: Dual-process accounts of reasoning. *Trends in Cognitive Sciences*, 7, 454–459. doi:10.1016/j.tics.2003.08.012
- Federmeier, K. D., Kutas, M., & Schul, R. (2010). Age-related and individual differences in the use of prediction during language comprehension. *Brain & Language*, 115, 149–161. doi:10.1016/j.bandl.2010.07.006
- Fisk, J. E., & Sharp, C. (2002). Syllogistic reasoning and cognitive aging. *Quarterly Journal of Experimental Psychology*, 55A, 1273–1293. doi:10.1080/02724980244000107
- Gerard, L. D., Zacks, R. T., Hasher, L., & Radvansky, G. A. (1991). Age deficits in retrieval: The fan effect. *Journal of Gerontology*, 46, 131–136. doi:10.1093/geronj/46.4.P131
- Gilchrist, A. L., Cowan, N., & Naveh-Benjamin, M. (2008). Working memory capacity for spoken sentences decreases with adult ageing: Recall of fewer but not smaller chunks in older adults. *Memory*, 16, 773–787. doi:10.1080/09658210802261124
- Gilinsky, A. A., & Judd, B. B. (1994). Working memory and bias in reasoning across the life span. *Psychology and Aging*, 9, 356–371. doi:10.1037/0882-7974.9.3.356
- Gonsalkorale, K., Sherman, J. W., & Klauer, K. C. (2009). Aging and prejudice: Diminished regulation of automatic race bias among older adults. *Journal of Experimental Social Psychology*, 45, 410–414. doi:10.1016/j.jesp.2008.11.004
- Guillory, J. J., & Geraci, L. (2010). The persistence of inferences in memory for younger and older adults: Remembering facts and believing inferences. *Psychonomic Bulletin & Review*, 17, 73–81. doi:10.3758/PBR.17.1.73

- Hamm, V. P., & Hasher, L. (1992). Age and the availability of inferences. *Psychology and Aging*, 7, 56–64. doi:10.1037/0882-7974.7.1.56
- Hasher, L., Stoltzfus, E. R., Zacks, R. T., & Rypma, B. (1991). Age and inhibition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 17, 163–169. doi:10.1037/0278-7393.17.1.163
- Hasher, L., & Zacks, R. T. (1988). Working memory, comprehension, and aging: A review and a new view. In G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 22; pp. 193–225). New York, NY: Academic Press.
- Hasher, L., Zacks, R. T., & May, C. P. (1999). Inhibitory control, circadian arousal, and age. In D. Gopher & A. Koriat (Eds.), *Attention and performance XVII* (pp. 653–675). Cambridge, MA: The MIT Press.
- Healey, M. K., Hasher, L., & Campbell, K. L. (2013). The role of suppression in resolving interference: Evidence for an age-related deficit. *Psychology and Aging*, 28(3), 721–728. doi:10.1037/a0033003
- Healey, M. K., Ngo, K. W. J., & Hasher, L. (2013). Below-baseline suppression of competitors during interference resolution by younger but not older adults. *Psychological Science*, 25, 145–151. doi:10.1177/0956797613501169
- Johnson-Laird, P. N. (1983). *Mental models: Towards a cognitive science of language, inference, and consciousness*. Cambridge, MA: Harvard University Press.
- Johnson-Laird, P. N. (2006). *How we reason*. Oxford: Oxford University Press.
- Kahneman, D. (2011). *Thinking fast and slow*. New York, NY: Farrar, Straus and Giroux.
- Khemlani, S., & Johnson-Laird, P. N. (2012). Theories of the syllogism: A meta-analysis. *Psychological Bulletin*, 138, 427–457. doi:10.1037/a0026841
- Kurby, C. A., Asiala, L. K. E., & Mills, S. R. (2013). Aging and the segmentation of narrative film. *Aging, Neuropsychology, and Cognition*, 21(4), 1–20.
- Kurby, C. A., & Zacks, J. M. (2007). Segmentation in the perception and memory of events. *Trends in Cognitive Science*, 12, 72–79. doi:10.1016/j.tics.2007.11.004
- Kurby, C. A., & Zacks, J. M. (2011). Age differences in the perception of hierarchical structure in events. *Memory & Cognition*, 39, 75–91. doi:10.3758/513421-010-0027-2
- Light, L. L., Zelinski, E. M., & Moore, M. (1982). Adult age differences in reasoning from new information. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 8, 435–447. doi:10.1037/0278-7393.8.5.435
- Lynchard, N. A., & Radvansky, G. A. (2012). Age-related perspectives and emotion processing. *Psychology and Aging*, 27, 934–939. doi:10.1037/a0027368
- Madden, C. J., & Dijkstra, K. (2010). Contextual constraints in situation model construction: An investigation of age and reading span. *Aging, Neuropsychology, and Cognition*, 17, 19–34. doi:10.1080/13825580902927604
- Madden, C. J., & Zwaan, R. A. (2006). Perceptual representation as a mechanism of lexical ambiguity resolution: An investigation of span and processing time. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 32, 1291–1303. doi:10.1037/0278-7393.32.6.1291
- Magliano, J. P., Kopp, K., McNeerney, M. W., Radvansky, G. A., & Zacks, J. M. (2012). Aging and perceived event structure as a function of modality. *Aging, Neuropsychology, and Cognition*, 19, 264–282. doi:10.1080/13825585.2011.633159
- May, C. P., & Hasher, L. (1998). Synchrony effects in inhibitory control over thought and action. *Journal of Experimental Psychology: Human Perception and Performance*, 24, 363–379. doi:10.1037/0096-1523.24.2.363

- McGinnis, D., Goss, R. J., Tessmer, C., & Zelinski, E. M. (2008). Inference generation in young, young-old, and old-old adults: Evidence for semantic architecture stability. *Applied Cognitive Psychology*, 22, 171–192. doi:10.1002/acp.1367
- McKoon, G., & Ratcliff, R. (2013). Aging and predictive inferences: A diffusion model analysis. *Journal of Memory and Language*, 68, 240–254. doi:10.1016/j.jml.2012.11.002
- Meneghetti, C., Borella, E., Grasso, I., & De Beni, R. (2012). Learning a route using a map and/or description in young and older adults. *Journal of Cognitive Psychology*, 24, 165–178. doi:10.1080/20445911.2011.603694
- Narvaez, D., Radvansky, G. A., Lynchard, N. A., & Copeland, D. E. (2011). Are older adults more attuned to morally-charged information? *Experimental Aging Research*, 37, 398–434. doi:10.1080/0361073X.2011.590756
- Noh, S. R., & Stine-Morrow, E. A. L. (2009). Age differences in tracking characters during narrative comprehension. *Memory & Cognition*, 37, 769–778. doi:10.3758/MC.37.6.769
- Overman, A. A., Wiseman, K. D., Allison, M., & Stephens, J. D. W. (2013). Age differences and schema effects in memory for crime information. *Experimental Aging Research*, 39, 215–234. doi:10.1080/0361073X.2013.761914
- Plant, E. A., & Devine, P. G. (1998). Internal and external motivation to respond without prejudice. *Journal of Personality and Social Psychology*, 75, 811–832. doi:10.1037/0022-3514.75.3.811
- Radvansky, G. A., & Copeland, D. E. (2004). Working memory and situation model processing: Language comprehension and memory. *American Journal of Psychology*, 117, 191–213. doi:10.2307/4149022
- Radvansky, G. A., & Copeland, D. E. (2006). Memory retrieval and interference: Working memory issues. *Journal of Memory and Language*, 55, 33–46. doi:10.1016/j.jml.2006.02.001
- Radvansky, G. A., Copeland, D. E., Berish, D. E., & Dijkstra, K. (2003). Aging and situation model updating. *Aging, Neuropsychology, and Cognition*, 10, 158–166. doi:10.1076/anec.10.2.158.14459
- Radvansky, G. A., Copeland, D. E., & von Hippel, W. (2010). Stereotype activation, inhibition, and aging. *Journal of Experimental Social Psychology*, 46, 51–60. doi:10.1016/j.jesp.2009.09.010
- Radvansky, G. A., Copeland, D. E., & Zwaan, R. A. (2003). Aging and functional spatial relations in comprehension and memory. *Psychology and Aging*, 18, 161–165. doi:10.1037/0882-7974.18.1.161
- Radvansky, G. A., Copeland, D. E., & Zwaan, R. A. (2005). A novel study: The mental organization of events. *Memory*, 13, 796–814. doi:10.1080/09658210444000412
- Radvansky, G. A., & Curiel, J. M. (1998). Narrative comprehension and aging: The fate of completed goal information. *Psychology and Aging*, 13, 69–79. doi:10.1037/0882-7974.13.1.69
- Radvansky, G. A., & Dijkstra, K. (2007). Aging and situation model processing. *Psychonomic Bulletin & Review*, 14, 1027–1042. doi:10.3758/BF03193088
- Radvansky, G. A., Gerard, L. D., Zacks, R. T., & Hasher, L. (1990). Younger and older adults' use of mental models as representations for text materials. *Psychology and Aging*, 5, 209–214. doi:10.1037/0882-7974.5.2.209
- Radvansky, G. A., & Zacks, J. M. (2011). Event perception. *Wiley Interdisciplinary Reviews: Cognitive Science*, 2, 608–620. doi:10.1002/wcs.133
- Radvansky, G. A., Zacks, R. T., & Hasher, L. (1996). Fact retrieval in younger and older adults: The role of mental models. *Psychology and Aging*, 11, 258–271. doi:10.1037/0882-7974.11.2.258

- Radvansky, G. A., Zacks, R. T., & Hasher, L. (2005). Age and inhibition: The retrieval of situation models. *Journal of Gerontology: Psychological Sciences*, 60B, P276–P278. doi:10.1093/geronb/60.5.P276
- Radvansky, G. A., Zwaan, R. A., Curiel, J. M., & Copeland, D. E. (2001). Situation models and aging. *Psychology and Aging*, 16, 145–160. doi:10.1037/0882-7974.16.1.145
- Salthouse, T. (1996). Constraints on theories of cognitive aging. *Psychological Review*, 3, 287–299.
- Salthouse, T. (2012). Consequences of age-related cognitive declines. *Annual Review of Psychology*, 63, 201–226. doi:10.1146/annurev-psych-120710-100328
- Salthouse, T., & Babcock, R. L. (1991). Decomposing adult age differences in working memory. *Developmental Psychology*, 27, 763–776. doi:10.1037/0012-1649.27.5.763
- Schmalhofer, F., & Glavanov, D. (1986). Three components of understanding a programmer's manual: Verbatim, propositional, and situational representations. *Journal of Memory and Language*, 25, 279–294. doi:10.1016/0749-596X(86)90002-1
- Shake, M. C., Noh, S. R., & Stine-Morrow, E. A. L. (2009). Age differences in learning from text: Evidence for functionally distinct text processing systems. *Applied Cognitive Psychology*, 23, 561–578. doi:10.1002/acp.1494
- Soederberg, L. M., & Stine, E. A. L. (1995). Activation of emotion information in text among younger and older adults. *Journal of Adult Development*, 2, 23–36. doi:10.1007/BF02261739
- Stine-Morrow, E. A. L., Gagne, D. D., Morrow, D. G., & DeWall, B. H. (2004). Age differences in re-reading. *Memory & Cognition*, 32, 696–710. doi:10.3758/BF03195860
- Stine-Morrow, E. A. L., Morrow, D. G., & Leno, R. (2002). Aging and the representation of spatial situations in narrative understanding. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*, 57, 291–297. doi:10.1093/geronb/57.4.P291
- Stine-Morrow, E. A. L., Shake, M. C., Miles, J. R., & Noh, S. R. (2006). Adult age differences in the effects of goals on self-regulated sentence processing. *Psychology and Aging*, 21, 790–803. doi:10.1037/0882-7974.21.4.790
- Stine-Morrow, E. A. L., Soederberg Miller, L. M., Gagne, D. D., & Hertzog, C. (2008). Self-regulated reading in adulthood. *Psychology and Aging*, 23, 131–153. doi:10.1037/0882-7974.23.1.131
- Sullivan, S. J., Mikels, J. A., & Carstensen, L. L. (2010). You never lose the ages you've been: Affective perspective taking in older adults. *Psychology and Aging*, 25, 229–234. doi:10.1037/a0018383
- Tsuji, T., Okada, M., & Watanabe, S. (2010). Effects of aging on hemispheric asymmetry in inferior frontal cortex activity during belief-bias syllogistic reasoning: A near-infrared spectroscopy study. *Behavioral Brain Research*, 210, 178–183. doi:10.1016/j.bbr.2010.02.027
- Unsworth, N., & Engle, R. W. (2007). The nature of individual differences in working memory capacity: Active maintenance in primary memory and controlled search from secondary memory. *Psychological Review*, 114, 104–132. doi:10.1037/0033-295X.114.1.104
- van Dijk, T. A., & Kintsch, W. (1983). *Strategies in discourse comprehension*. New York, NY: Academic Press.
- Viskontas, I. V., Holyoak, K. J., & Knowlton, B. J. (2005). Relational integration in older adults. *Thinking & Reasoning*, 11, 390–410. doi:10.1080/13546780542000014
- von Hippel, W., Silver, L. A., & Lynch, M. E. (2000). Stereotyping against your will: The role of inhibitory ability in stereotyping and prejudice among the elderly. *Personality and Social Psychology Bulletin*, 26, 523–532. doi:10.1177/0146167200267001

- Zacks, J. M., Kurby, C. A., Eisenberg, M. L., & Haroutunian, N. (2011). Prediction error associated with the perceptual segmentation of naturalistic events. *Journal of Cognitive Neuroscience*, 23, 4057–4066. doi:10.1162/jocn\_a\_00078
- Zacks, J. M., Speer, N. K., Swallow, K. M., Braver, T. S., & Reynolds, J. R. (2007). Event perception: A mind-brain perspective. *Psychological Bulletin*, 133, 273–293. doi:10.1037/0033-2909.133.2.273
- Zacks, J. M., Speer, N. K., Vettel, J. M., & Jacoby, L. L. (2006). Event understanding and memory in healthy aging and dementia of the Alzheimer type. *Psychology and Aging*, 21, 466–482. doi:10.1037/0882-7974.21.3.466
- Zacks, J. M., & Swallow, K. M. (2007). Event segmentation. *Current Directions in Psychological Science*, 16, 80–84. doi:10.1111/j.1467-8721.2007.00480.x
- Zwaan, R. A., Magliano, J. P., & Graesser, A. C. (1995). Dimensions of situation model construction in narrative comprehension. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 21, 386–397. doi:10.1037/0278-7393.21.2.386
- Zwaan, R. A., & Radvansky, G. A. (1998). Situation models in language comprehension and memory. *Psychological Bulletin*, 123(2), 162–185. doi:10.1037/0033-2909.123.2.162



## Reading in normally aging adults

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Skilled reading requires coordination of knowledge about language with a broad range of basic cognitive processes. While changes due to aging have been documented for many of those cognitive processes, the ability to read declines little during healthy aging. Aging is associated with slower reading, longer eye movements and more regressive eye movements, but the qualitative patterns of older adults' eye movements in response to lexical characteristics (e.g., frequency) and sentence characteristics (e.g., word predictability) largely resemble those of younger adults. The age-related differences in reading behavior are due in part to older adults' reduced visual abilities. In addition, they may result from compensatory strategies wherein older rely more on their intact semantic intelligence and less heavily on perceptual processing of text, or alternatively they may be a consequence of older adults' being less adept at effectively coordinating word recognition with processes of oculomotor control. Some age-related declines are seen when reading comprehension and text memory are assessed at lower levels of representation for complex sentences. However, older adults perform as well or better than younger adults when higher-level meanings of a text are assessed. These high levels of performance reflect older adults' ability to draw on crystallized semantic intelligence that provides well-organized structures in long-term memory of the patterns that tend to occur in natural language.

The activity of reading raises fundamental theoretical and practical questions about healthy cognitive aging. Reading relies greatly on knowledge of patterns of language and of meaning at the level of words and topics of text. Further, this knowledge must be rapidly accessed so that it can be coordinated with processes of perception, attention, memory and motor control that sustain skilled reading at rates of four-to-five words a second. As such, reading depends both on crystallized semantic intelligence which grows or is maintained through healthy aging, and on components of fluid intelligence which decline with age. Reading

is important to older adults because it facilitates completion of everyday tasks that are essential to independent living. In addition, it entails the kind of active mental engagement that can preserve and deepen the cognitive reserve that may mitigate the negative consequences of age-related changes in the brain. This chapter reviews research on the *front end* of reading (word recognition) and on the *back end* of reading (text memory) because both of these abilities are surprisingly robust to declines associated with cognitive aging. For word recognition, that robustness is surprising because rapid processing of the sort found in reading is usually impaired by aging; for text memory, it is surprising because other types of episodic memory performance (e.g., paired associates) substantially decline in aging. These two otherwise quite different levels of reading comprehension remain robust because they draw on the knowledge of language that older adults gain through a life-time of experience with language.

### Aging and word recognition during reading

Over the past 50 years, studies using eye tracking during sentence reading have yielded a rich understanding of the characteristics of eye movements of skilled, young-adult readers (Engbert, Nuthmann, Richter, & Kliegl, 2005; Radach, Kennedy, & Rayner, 2004; Rayner, 1978, 1998, 2009). During reading, the eyes move across a text, alternating between periods of relative stillness known as fixations, and rapid movements between fixations known as saccades. Typically, each word is fixated once, for a duration of 200–350 milliseconds (Inhoff, 1984; Rayner, 1978, 1998). In addition, words that are short or low in informational value (e.g., function words) may be skipped over, and long words often receive more than one fixation. Timing and targeting of saccades is determined by a mixture of oculomotor and lexical factors. For example, short saccades tend to overshoot their targets, resulting in the skipping of short words (e.g., Brysbaert, Drieghe, & Vitu, 2005; Brysbaert & Vitu, 1998), and words that are high in frequency or highly predictable based on sentential context are more likely to be skipped or receive shorter fixations than low frequency or less predictable words (e.g., Drieghe, Rayner, & Pollatsek, 2005; White, Rayner, & Liversedge, 2005). During normal reading, most saccades are progressive, moving rightward onto words that have not yet been fixated. Occasional regressive saccades occur in cases when words have inadvertently been skipped over or when the reader experiences difficulty integrating the meaning of a word into the larger context of the discourse (Rayner, 1998).

While a great deal is known about eye movements during reading by younger adults, eye-tracking studies of reading in older adults only began in earnest in the last decade (Kliegl, Grabner, Rolfs, & Engbert, 2004; Rayner, Castelhamo, &

Yang, 2010; Rayner, Reichle, Stroud, Williams, & Pollatsek, 2006; Rayner, Yang, Castelhana, & Liversedge, 2011) and consequently less is known about whether and how aging affects word recognition during reading. As with other language abilities, word recognition appears to be well preserved throughout healthy aging. Vocabulary knowledge is constant or continues to grow throughout the healthy lifespan, with older adults often outperforming younger adults on tests of vocabulary (Uttl, 2002; Verhaeghen, 2003). In simple isolated-word recognition tasks such as lexical decision, word naming, and semantic categorization, older adults respond more slowly than younger adults, but the observed differences are smaller than the amount of age-related slowing found for non-lexical, visuo-spatial reaction time tasks (Hale & Myerson, 1996; Lima, Hale, & Myerson, 1991), provided that the linguistic tasks do not require high involvement of the executive system (Verhaeghen, Cerella, Semeneć, Leo, Bopp, & Steitz, 2002). The observation of preserved semantic priming effects further supports the notion that semantic representations are well-maintained with age (Balota, Watson, Duchek, & Ferraro, 1999; Burke, White & Diaz, 1987; Laver & Burke, 1993; Myerson, Ferraro, Hale, & Lima, 1992), although some degree of semantic degradation has been observed in adults over 70 years old (Verhaeghen & Poncellet, 2013). However, successful comprehension during sentence reading depends on the recognition of words as the eyes move rapidly over a text, requiring effective coordination of word recognition with processes of oculomotor control and the integration of individual words into the unfolding context of the sentence. For skilled readers, eye movements are coordinated in a way that optimizes both reading speed and text comprehension, relying on the efficient combination of word knowledge or crystallized intelligence and processing skill, a component of fluid intelligence. Therefore, the relative preservation of word recognition ability in older adults does not ensure that reading ability as a whole is constant with age.

Older adults generally read more slowly than younger adults, a finding that may be attributable at least partially to a general pattern of age-related cognitive slowing (Baltes & Lindenberger, 1997; Lindenberger & Baltes, 1994; Salthouse, 1992, 1996; Verhaeghen & Cerella, 2002). In addition, changes in reading rate among older adults are rooted to some degree in basic age-related changes in visual perception. Even among older adults with good high-contrast acuity, normal age-related changes to the visual system, such as reduced contrast sensitivity and reduced retinal illumination, make visual perception of written text more effortful (Fozard & Gordon-Salant, 2001; Haegerstrom-Portnoy, Schneck, & Brabyn, 1999; Solan, Feldman, & Tujak, 1995; Owsley, 2011), leading to decreased sensitivity to fine visual detail (McGowan, White, Jordan, & Paterson, 2014) and increased effects of visual crowding (Cerella, 1985; Scialfa, Cordazzo, Bubruc, & Lyon, 2013). Even in adults with normal or corrected-to-normal vision, these

subtle forms of visual decline can cause reading rates to slow (Akutsu, Legge, Ross, & Schuebel, 1991).

Older adults may adapt to these visual challenges by relying more heavily than younger adults on low-frequency spatial information in written text. Lower spatial frequencies provide course-grained information about the words' shape and location, whereas higher spatial frequencies provide fine-grained information about individual letter features. Direct support for older adults' greater reliance on course-grained visual information comes from studies that have investigated how reading is affected by filtering text so that information is only available for a limited range of spatial frequencies (Paterson, McGowan, & Jordan, 2013a). Although older adults showed greater disruption than younger adults for any kind of filtered text, they were particularly impaired when only high frequency visual information was displayed, and showed relatively less impairment for text showing only low frequencies (Jordan, McGowan, & Paterson, 2014; Paterson, McGowan, & Jordan, 2013b). Indirect evidence that older adults rely heavily on low-frequency spatial information comes from studies showing that older adults are more impaired than younger adults when reading (unfiltered) unspaced text (McGowan et al., 2014; Rayner, Yang, Schuett, & Slattery, 2013). Inter-word spaces are a salient, low-spatial frequency cue to the location of word boundaries, and therefore may be especially important to older adults as a guide for targeting saccades. Removing spaces precluded this strategy and caused particular impairment to reading in older adults.

During normal reading, older adults appear to be relatively successful in the use of compensatory strategies to mitigate the consequences of reduced visual abilities or processing speed. Although older adults read more slowly than younger adults, their qualitative patterns of eye movements across written text tend to be very similar to those of younger adults (Kliegl et al., 2004; Laubrock, Kliegl, & Engbert, 2006; Rayner et al., 2006). For example, older adults show similar (although not identical) effects of word frequency and contextual predictability as do younger adults (Rayner et al., 2006). However, while there is clear similarity in the overall patterns of eye movements during reading for younger and older adults (Kliegl et al., 2004), some qualitative differences do exist. Older adults typically make more fixations and more regressive saccades (Kliegl et al., 2004; Rayner et al., 2006; Rayner et al., 2013; McGowan et al., 2013; Solan et al., 1995), and they make longer saccades and show higher rates of word skipping compared to younger adults (Rayner et al., 2006). Age-related changes in visual perception may underlie some of these differences. Rayner et al. (2006) manipulated visual encoding difficulty by using normal (Times New Roman) and difficult-to-read (Old English) fonts. Younger adults' eye movements on Old English font looked similar to the eye movement behavior of older adults on Times New Roman font,

suggesting that some of the qualitative changes in fixation patterns are indeed the result of greater difficulty with visual word encoding at the perceptual level. However, font-difficulty did not account for all differences in eye movement behavior, as older adults reading Times New Roman font showed greater saccade length and more regressive saccades than younger adults reading Old English font. Therefore, age-related differences in reading likely result from changes in cognitive ability in addition to changes in ability at the level of visual perception.

One possible explanation for older adults' related tendencies toward longer saccades and higher rates of skipping is that they compensate for their slower visual and motor processes by adopting a *risky-reading* strategy (Rayner et al., 2011; Rayner et al., 2006; see also Chapter 7), relying more heavily on their intact semantic and conceptual representations and less heavily on perceptual processing of text. Older adults' tendency to show larger and more consistent effects of word frequency on word skipping rates (Kliegl et al., 2004; Rayner et al., 2006; but see Rayner et al., 2011) suggests that they tend to rely on (partial) visual and word frequency information to 'guess' the identity of upcoming words, thereby skipping more words in an attempt to speed up reading rate. In addition, older adults are more likely than younger adults to make regressive saccades toward initially skipped words, suggesting that they tend to make incorrect guesses about the identity of skipped words, leading to processing problems downstream. Importantly, 'guessing' the upcoming words in this case is not meant to refer to a consciously applied strategy, but rather to an unconscious change in behavior to optimize performance despite cognitive and/or physiological limitations. Although there is no direct evidence that these age-related changes in eye movement behavior are indeed the result of a compensatory strategy, such strategic adaptation to patterns of preserved and reduced abilities is characteristic of how older adults approach many activities. For example, during a test of typing speed, Salthouse (1984) found that older adults showed greater impairment relative to younger adults in cases where the number of visible characters in the upcoming text was limited, suggesting they look further ahead in the text than younger adults in an attempt to compensate for reduced cognitive and motor speed.

However, research that directly examines task strategies has shown that aging leads to conservative rather than risky response criteria (Ratcliff, Thapar, Gomez, & McKoon, 2004), and the evidence that older adults adopt a risky-reading strategy is not conclusive. For example, Rayner et al. (2006) did not find evidence for older adults' greater dependence on contextual information when assessing the effects of predictability, as both older and younger readers were more likely to skip or spend less time fixating highly predictable compared to less predictable words. Similarly, Kliegl et al. (2004) found that both older and younger adults made use of word predictability to increase reading speed, although they did so

through slightly different adaptations in their eye movement patterns. Younger adults showed an effect of contextual predictability as an increase in skipping rates for predictable words, whereas older adults responded to the same manipulation with a reduced probability of refixation, so that they were less likely to refixate predictable words compared to less predictable words. However, aside from these qualitative differences in eye movement behavior, both younger and older adults were shown to rely to a similar degree on contextual predictability information as a determinant of reading speed. If older adults relied more heavily on contextual information in order to speed up their reading rate, this would be expected to result in greater effects of predictability compared to those observed in younger adults.

Further evidence both for and against the notion that older adults adopt a risky-reading strategy comes from research that has examined the effects of aging on the size of readers' perceptual spans and the processing benefits obtained from parafoveal preview. During sentence reading, the perceptual span refers to the region of effective vision. For younger adult skilled readers, the perceptual span extends approximately 3–4 letters to the left of fixation, and approximately 14–15 letters to the right of fixation (McConkie & Rayner, 1975; Rayner & Bertera, 1979). Depending on word length, this means that readers can obtain useful information from one or more words to the right of the currently fixated word, in the visual region known as the parafovea. Effective parafoveal processing can speed up reading times, as words that have received greater processing in the parafovea (i.e. before the word was fixated) may be inspected for less time once they are eventually fixated (Inhoff & Rayner, 1986; Schotter, Angele, & Rayner, 2012). Occasionally readers may even reach full recognition of the parafoveal word, in which case it may be skipped (Choi & Gordon, 2013; Gordon, Plummer, & Choi, 2013; Pollatsek, Reichle, & Rayner, 2006; Reichle, Pollatsek, Fisher, & Rayner, 1998).

In non-reading tasks such as visual search or choice reaction time, older adults have been shown to process non-foveal information less effectively than younger adults (Ball, Beard, Roenker, Miller, & Griggs, 1988; Sekuler, Bennett, & Mamelak, 2000), but evidence on older adults' ability to effectively make use of parafoveal information during sentence reading has been less consistent. Rayner, Castelhamo, and Yang (2009) manipulated the amount of parafoveal information available to the reader by using a fixed-size window that moved wherever the reader was looking, a technique known as the moving-window paradigm (McConkie & Rayner, 1975, 1976; Rayner, 2014). By varying the size of the moving window (i.e., how many words beyond the currently fixated word are visible at any given time), it is possible to estimate the average perceptual span across groups of readers. For younger adults, reading typically proceeds normally as long as the visible region includes the fixated word and at least two following words, but reading

tends to be disrupted when the visible region includes only one word beyond the currently fixated word (Rayner, 1986; Rayner, Well, Pollatsek, & Bertera, 1982; Rayner et al., 2009). This suggests that readers obtain useful information from up to two words to the right of fixation, but no further than that. In contrast, Rayner et al. (2009) observed that older adults showed no differences in eye movement behavior when the visible region included either one or two words to the right of fixation, but in both cases reading was significantly disrupted compared to a control condition in which the entire sentence was always visible. Since the inclusion of the second word to the right of fixation did not facilitate reading for older adults the way it does for younger adults, it appears that older adults do not obtain useful word information beyond the first word to the right of fixation. In addition, older adults showed impaired reading when information to the *left* of fixation was masked, while younger adults were not affected by this manipulation. This finding suggests that older adults' perceptual span is less asymmetric than younger adults', so that it includes relatively more information to the left of fixation. Using a technique known as the boundary paradigm (Rayner, 1975), Rayner and colleagues (2010) compared reading behavior across older and younger adults when target words were masked until the reader's eyes crossed an invisible boundary between the target and the immediately preceding word. Older adults were less disrupted than younger adults when parafoveal processing of targets was prevented, suggesting their reading relies less heavily on information available in the parafovea. Finally, Rayner, Yang, Schuett, and Slattery (2014) showed that older adults were significantly more impaired than younger adults in cases where a moving window consistently masked the word they were fixating at that time, suggesting that older adults were less able to rely on parafoveal information in cases where the foveal word was unavailable.

The notion that older adults are less effective than younger adults at using information available in the parafovea to increase their reading rate has been used to support the risky-reading interpretation of older adults' reading behavior. According to this argument, because older adults' parafoveal processing is less efficient, they are more likely to guess the identity of upcoming words rather than attempting full identification (Rayner et al., 2011; Rayner et al., 2006). However, not all available evidence is consistent with this idea. For example, Rayner et al. (2014) did not find a significant difference in the amount of disruption in older and younger adult readers when *all* words to the right of fixation were masked by a moving window, which is inconsistent with the notion that older adults rely less heavily on information to the right of the fixation. Furthermore, Risse and Kliegl (2011) provide evidence that older adults' parafoveal processing abilities may actually be relatively well preserved. Using an adaptation of the boundary paradigm, Risse and Kliegl manipulated the preview availability of the second word

(N+2) following a target word, and showed that older and younger adults showed similar amounts of N+2 preview benefit. That is, word N+2 was read more quickly in cases where valid preview was available while readers were fixating two words earlier in the sentence. The finding that older adults appear to be able to make use of parafoveal information as far as two words ahead of the current fixation is inconsistent with the theory that older adults' parafoveal processing is impaired compared to younger adults.

Based on the observation of preserved parafoveal processing in older adults, Risse and Kliegl have proposed an interpretation of older adults' eye movements that can be construed as an alternative to the risky-reading theory. They suggest that older adults' patterns of eye movements during reading may result from a reduced ability to flexibly adjust their fixation patterns in response to foveal and parafoveal processing demands. This alternative interpretation is supported by two main observations from the same study. First, older adults showed a comparatively lower post-skipping cost, referring to the tendency for fixation durations to be longer right after a word has been skipped (Pollatsek et al., 2006; Radach & Heller, 2000; Reichle et al., 1998; Vitu, McConkie, Kerr, & O'Regan, 2001). Post-skipping cost is typically attributed to the fact that, in cases where the previous word was skipped, the currently fixated word received less parafoveal processing compared to cases in which the previous word was not skipped, as it is separated from the saccade's launch site by the skipped-over word. Therefore, if older adults indeed have reduced parafoveal preview capacity, one would expect to find larger post-skipping costs compared to younger adults rather than the observed reduction in post-skipping cost. Second, Risse and Kliegl observed a parafoveal-on-foveal effect that was smaller for older compared to younger adults. Parafoveal-on-foveal effects occur when the difficulty of the word to the right of the fixation influences fixation durations on the currently fixated word (Kennedy, Pynte, & Ducrot, 2002; Kliegl, Nuthman, & Engbert 2006; Wotschack & Kliegl, 2013). In Risse and Kliegl's study, younger adults compared to older adults showed larger reductions in target word gaze duration when the word following the target was an easy-to-process function word compared to a more-difficult-to-process noun. Although it should be kept in mind that parafoveal-on-foveal effects themselves are somewhat controversial (e.g., Kliegl, 2007; Rayner, Pollatsek, Drieghe, Slattery, & Reichle, 2007), these findings suggest that although parafoveal processing of words may be intact in older adults, elderly readers may be less likely to use the acquired parafoveal information to flexibly adapt their fixation durations based on local and short-term changes in processing difficulty.

Consistent with the idea that older adults respond less flexibly to local changes in processing difficulty, older adults appear to be more impaired than younger adults when reading disappearing text (Rayner et al., 2011). In a disappearing text

paradigm (Ishida & Ikeda, 1989; Rayner, Inhoff, Werner, Morrison, Slowaczek, & Bertera, 1981), each word in a sentence is masked within a short duration of time after the onset of the first fixation on that word. Surprisingly, reading for younger adult skilled readers is only minimally disrupted when words are visible for as little as 60 ms each, suggesting that this is enough time for readers to obtain the visual information necessary for subsequent lexico-semantic encoding. Rayner and colleagues found that older readers were much more disrupted than younger adults when reading disappearing text with 60 ms mask onsets, although the amount of additional disruption caused by even earlier mask onsets (40 and 50 ms) was similar for older and younger adults. When only one target word in a sentence was replaced by a mask, this was more disruptive than when all words were masked, but importantly this additional disruption was much greater for older compared to younger adults. Together, these results suggest that older adults adapted less well to sudden, localized changes in the stimuli.

The lack of flexible adaptation to local variation in processing difficulty observed by Risse and Kliegl (2011) and Rayner et al. (2011) may be attributed to reductions in inhibitory control of eye movements during reading, as proposed by Laubrock et al. (2006). In general, these ideas are consistent with the notion of a general age-related decline in inhibitory control in cognitive tasks (Hasher, Stoltzfus, Zacks, & Ryma, 1991). Evidence from non-reading tasks suggests that older adults exhibit weaker saccadic control (Scialfa, Hamaluk, Pratt, & Skaloud, 1999; Butler, Zacks, & Henderson, 1999) and slower saccadic latency (Cassavaugh, Kramer, & Peterson, 2004) compared to younger adults. Rayner et al. (2006) found few age-based differences in average landing position, meaning older and younger adults' first fixations into a word tend to land at similar sites relative to the word's center, suggesting that the oculomotor control needed for effective saccade targeting is not affected by age. However, older adults' ability to effectively coordinate eye movements during reading with processes of lexico-semantic encoding has not been directly assessed and more research is needed to determine how possible changes in oculomotor control affect older adults' reading behavior. For now, the idea that a reduced ability to flexibly respond to processing demands provides an alternative to the risky reading interpretation of older adults' reading behavior. Longer saccades, greater skipping and more frequent regressive saccades may be indicators of reduced sensitivity to local processing challenges. As a result, older adults' first-pass sentence reading may be a relatively coarse-grained scan, followed by regressive saccades in cases where the initial analysis proved insufficient and specific words must be encoded in a more fine-grained manner.

To summarize, studies of older adults' eye movements during sentence reading suggest that their word recognition is relatively unimpaired. Although older adults read more slowly than young adults, their qualitative patterns of eye

movements in response to lexical characteristics (e.g., frequency) and sentence characteristics (e.g., word predictability) largely resemble those of younger adults, demonstrating the influence of preserved crystallized intelligence in the form of word knowledge. Remaining age-related differences in reading behavior may be attributed in part to older adults' reduced visual abilities and in part to potential compensatory strategies as suggested by the risky-reading account. Alternatively, older adults may be less adept at effectively coordinating word recognition with processes of oculomotor control, impairing their ability to flexibly adapt their patterns of fixation in response to immediate processing demands. By this account, age-related changes in reading ability are the result of a reduction in skills related to rapid processing and coordination of multiple cognitive processes, a component of fluid intelligence that declines with age.

### **Aging, reading and memory**

Remembering what has been read enhances the value of reading. Although age-related deficits in text memory are well-documented (see Johnson, 2003, for a meta-analysis and review), the magnitude of these deficits is not nearly as pronounced as those that have been reported in list-memory paradigms (Alexander et al., 2012; Zelinski & Kennison, 2007), which is consistent with the broader observation noted above that many domains of language comprehension are maintained or even enhanced with increasing age (see, e.g., Burke & Shafto, 2008; Thornton & Light, 2006; Salthouse, 2009; Verhaeghen, 2003). Here we consider the effects of aging on sentence processing and text memory at different levels of linguistic representation, focusing in particular on factors that contribute to older adults' relatively preserved language comprehension abilities.

Successful language comprehension must occur to give rise to an enduring memory of what was read. This process is often described in terms of building, maintaining, and integrating linguistic representations at several different levels, including the surface level, textbase, and situation-model (Kintsch, 1988, 1998). The surface level represents the exact words of the text, as well as the syntactic relations that link them together grammatically. The textbase contains the integrated ideas and meaningful propositions expressed by the text. Finally, the situation model involves a more elaborate understanding of what the text is about including higher-level representations of events, actions, goals, and causal relationships (see Chapter 3 & 8).

Work that has focused on sentence processing at the surface level, specifically with regard to the syntactic operations that are needed to construct higher-level propositions, has found that processing is minimally affected by age, except

for sentences with very complex syntactic constructions (e.g., Caplan, DeDe, Waters, Michaud, & Tripodis, 2011; Kemper, 1987; Kemper, Crow, & Kemtes, 2004; Kemper & Liu, 2007; Kemtes & Kemper, 1997). In cases where processing at the surface level breaks down, readers of all ages are likely to adopt a representation of the sentence that is incomplete, inaccurate, or otherwise deemed “good enough” for the task at hand (Christianson, Hollingsworth, Halliwell, & Ferreira, 2001; Christianson, Williams, Zacks, & Ferreira, 2006; Ferreira, Bailey, & Ferraro, 2002; Ferreira & Patson, 2007). For example, after reading temporarily ambiguous garden-path sentences such as *While Anna dressed the baby played in the crib*, Christianson et al. (2006) found that younger adults adopted an incorrect interpretation of the sentence about 30% of the time (e.g., incorrectly answering “yes” to the question, “Did Anna dress the baby?”), whereas older adults were incorrect about 50% of the time.

Additional work has investigated possible age differences in sentence processing at the textbase level, focusing in particular on *wrap-up effects* during reading. Wrap-up refers to the increase in reading time that is typically observed at the ends of clauses and sentences (Just & Carpenter, 1980; Rayner, Kambe, & Duffy, 2000; Rayner, Sereno, Morris, Schmauder, & Clifton, 1989), which has been proposed to reflect semantic integration of the concepts in the sentence into a coherent textbase representation (e.g., Daneman & Carpenter, 1983; Haberlandt & Graesser, 1989; Payne & Stine-Morrow, 2012, 2014). Younger adults tend to show larger wrap-up effects than older adults (e.g., Stine, 1990; Stine, Cheung, & Henderson, 1995), suggesting that younger adults might encode stronger representations of the textbase during reading. However, several studies have shown that there are large individual differences in wrap-up effects among both younger and older adults, and that individuals across all age groups who show larger wrap-up effects tend to also show better comprehension and subsequent memory for what was read (e.g., Haberlandt, Graesser, Schneider, & Kiely, 1986; Miller & Stine-Morrow, 1998; Payne & Stine-Morrow, 2012, 2014; Smiler, Gagne, & Stine-Morrow, 2003; Stine, 1990; Stine-Morrow, Milinder, Pullara, & Herman, 2001). In fact, some work suggests that providing explicit instructions on reading strategies that support conceptual integration can improve memory for what was read among both younger and older adults (Stine-Morrow, Noh, & Shake, 2010). Additional work suggests that older adults may show increased wrap-up effects to compensate for decreased levels of crystallized intelligence (e.g., Chin et al., 2015; discussed in greater detail below).

Any age differences in sentence processing and memory that may arise at the surface-form and textbase levels seem to disappear when higher levels of linguistic representation are assessed, which may reflect different strategies of resource allocation during reading among older and younger adults (e.g., Radvansky &

Dijkstra, 2007; Stine-Morrow, Miller, & Hertzog, 2006; Stine-Morrow, Miller, Gagne, & Hertzog, 2008). Early support for this notion came from Stine-Morrow, Loveless, and Soederberg (1996), who collected self-paced-reading times and subsequent recall measures from older and younger adults. The results showed that the young adults who showed the highest levels of recall for the text tended to devote more online processing to surface level factors (e.g., showed large word-frequency effects) and textbase factors (e.g., slowed down on portions of the text that were propositionally dense), whereas the older adults who showed the highest levels of recall tended to devote more online processing to aspects of the text that may have helped them build a strong situation model (e.g., spending more time on earlier portions of the text when characters were being introduced compared to later portions of the text). Similar work by Radvansky, Zwaan, Curiel, and Copeland (2001) assessed readers' recognition memory for aspects of the texts that corresponded to the surface level (e.g., verbatim words from the text), the textbase level (e.g., a paraphrase from the text), and the situation model (e.g., an inference drawn from the text). Results showed that younger adults had better memory than older adults when the recognition task assessed the surface or textbase level; however, older adults outperformed younger adults when the memory task assessed aspects of the situation model.

A number of other studies have provided additional evidence that when memory for text is assessed at higher levels of text meaning, older adults do as well or better than young adults (e.g., Ferstl, 2006; Radvansky, Copeland, Berish, & Dijkstra, 2003; Radvansky, Copeland, & Zwaan, 2003; Radvansky, Gerard, Zacks, & Hasher, 1990; Stine-Morrow, Gagne, Morrow, & DeWall, 2004; see Radvansky, 1999; Radvansky & Dijkstra, 2007, for reviews). For example, Radvansky, Copeland, and Zwaan (2003) examined older and younger adults' representations of the spatial relations they formed while reading texts. Participants had shorter reading times for sentences where two entities could easily be integrated into a functional spatial relationship (e.g., a hammer poised above a nail), compared to sentences where the two entities did not have a functional spatial relationship (e.g., a hammer to the right of a nail). Further, a subsequent memory test showed that participants had better memory for the functional relations compared to the nonfunctional relations. Critically, there was no evidence of an age difference in the magnitude of these effects for either the reading-time data or the memory data, consistent with the notion that older adults retain the ability to construct situation models during language comprehension and rely on these representations later when they remember what they read. Notably, Radvansky et al. (2001) have proposed that older adults do build adequate linguistic representations at the lower-level surface and textbase levels, which they may then use as a temporary "scaffold" on their

way to building a strong situation model, at which point the surface and textbase representations fade rapidly.

A variety of perspectives on aging, sentence processing, and text memory have noted that working-memory capacity tends to decline with increasing age (e.g., Craik & Byrd, 1982), and this has commonly been used as an explanatory framework when age deficits are observed in language tasks (e.g., Borella, Ghisletta, & de Ribaupierre, 2011; Christianson et al., 2006; Hertzog, Dixon, Hulstsch, & MacDonald, 2003; Kemper et al., 2004; Kemper & Liu, 2007; Norman, Kemper, & Kynette, 1992; Stine-Morrow, Ryan, & Leonard, 2000; Stine-Morrow et al., 2006; van der Linden et al., 1999). Although some of this work has found relationships between working-memory capacity and language performance among older adults, several other studies have found no evidence of a relationship between working-memory capacity and age-related differences in online processing patterns or memory performance (e.g., Radvansky & Copeland, 2001, 2004, 2006; Smiler et al., 2003; Stine-Morrow et al., 1996; Stine-Morrow, Miller, & Leno, 2001), and still others have shown that age-related differences may be more appropriately conceptualized as stemming from differences in other constructs such as crystallized intelligence (i.e., knowledge) rather than working-memory capacity (e.g., Chin et al., 2015; Miller, 2009; Miller, Cohen, & Wingfield, 2006; Miller & Gagne, 2008; Miller & Stine-Morrow, 1998; Miller, Stine-Morrow, Kirkorian, & Conroy, 2004). Further, as noted above, age differences in memory for text tend to be much smaller than differences that have been reported using other paradigms, such as list learning (Alexander et al., 2012; Zelinski & Kennison, 2007), and the sentence-processing mechanisms that are necessary to build enduring memory representations of what was read tend to be relatively insensitive to the effects of aging except for sentences with very complex syntactic structures (e.g., Caplan et al., 2011; Kemper, 1987; Kemper et al., 2004; Kemper & Liu, 2007; Kemtes & Kemper, 1997). All of this suggests that conceptualizing age-related changes in sentence processing and text memory within a framework that focuses on declines in working-memory capacity is inadequate.

The notion that there is a relationship between the relative preservation with aging of both sentence comprehension and text recall is consistent with an emphasis in the broader psycholinguistics literature to move away from capacity-limited working-memory models of sentence processing (e.g., Baddeley, 1986, 2000; King & Just, 1991; Just & Carpenter, 1992) and toward models that characterize comprehension as dependent on how syntactic, semantic, and pragmatic information is encoded, stored, and retrieved during sentence processing (e.g., Gordon & Lowder, 2012; Gordon, Hendrick, & Johnson, 2001; Johnson, Lowder, & Gordon, 2011; Ledoux & Gordon, 2006; Lewis & Vasishth, 2005; Lewis, Vasishth, & Van Dyke, 2006; Van Dyke & Lewis, 2003), with these same processes

of encoding and retrieval underlying text memory. Such *cue-based* approaches to sentence processing fit well with the idea of long-term working memory (LTWM; Ericsson & Kintsch, 1995), which proposes that the ongoing memory resources required for skilled performance cannot be met by temporary, limited-capacity systems, but instead require a highly organized system that allows information to be retrieved from long-term memory rapidly and efficiently.

Conceptualizing sentence processing and text memory within a cue-based LTWM framework leads to the expectation that language comprehension and text memory work well when the processes of encoding and retrieval involve meaningful representations that are supported by multiple cues; otherwise, both work poorly. This account is consistent with work demonstrating that older adults show limited or no impairments when the language task provides them with opportunities to draw on their broad knowledge of language and more general world knowledge (e.g., Arbuckle, Vanderleek, Harsany, & Lapidus, 1990; Hess & Flannagan, 1992; Hess, Flannagan, & Tate, 1993; Light & Anderson, 1983; Miller et al., 2006; Miller & Stine-Morrow, 1998; Morrow, Leirer, Andrassy, Heir, & Menard, 1998). For example, Miller and Stine-Morrow presented older and younger participants with vague, difficult-to-understand passages to read. Half of the participants received a title to go along with each passage that provided a schematic context that helped clarify the meaning of the text (Bransford & Johnson, 1972), while half of the participants received no titles. Readers who received titles had shorter reading times compared to readers who did not receive titles, particularly at the ends of clauses and sentences where conceptual integration of the material is proposed to take place. In addition, memory for the passages was better when a title had been provided. Importantly, this manipulation of contextual knowledge was more beneficial to older than younger adults, suggesting that older adults' ability to use meaningful cues to guide the encoding and retrieval of text is very well-preserved.

Whereas Miller and Stine-Morrow (1998) showed that conceptual integration of vague texts is easier when the reader is armed with the relevant schematic knowledge (i.e., knowledge that the reader has possessed for his or her entire life), other evidence suggests that recently-learned knowledge has a very different pattern of effects on conceptual integration. Miller et al. (2004) examined the effects of health knowledge on processing and memory of health-related texts by assigning older and younger adults to either a training program where they were taught knowledge that would be relevant to comprehending the texts, or to a control program. Although older and younger adults who had received the relevant training showed better comprehension for the material they read compared to control participants, the online reading times between the two age groups showed different patterns of effects. Specifically, older adults who had recently acquired the

information relevant to understanding the texts showed larger wrap-up effects than control older adults, whereas there was no difference in the magnitude of wrap-up effects between knowledgeable and less-knowledgeable younger adults. This suggests that older adults who have recently acquired relevant domain knowledge about a text may allocate more processing resources to portions of the text that require conceptual integration; however, this extra processing effort pays off in terms of achieving high levels of comprehension and memory for what was read (see also Miller, 2009). Taken together, these findings point toward very different roles for schematic knowledge and domain knowledge during reading among older adults. When the information in a text reflects a topic older adults know extremely well that draws on their wealth of schematic knowledge, it seems that this knowledge is easily accessed during reading and can automatically be applied to the information contained in the text to facilitate processing. In contrast, when the information in a text is about a more complex domain of knowledge, especially on a topic that older adults have only recently learned about, there may not be a straightforward conceptual mapping between the information contained in the text and the reader's knowledgebase, resulting in slower, more effortful integration.

Aside from being able to draw on relevant knowledge during language comprehension, older adults also rely on their intact crystallized semantic intelligence (e.g., Beier & Ackerman, 2005; Verhaghen, 2003). Chin et al. (2015) examined the effects of both domain knowledge and crystallized intelligence on older adults' reading times and subsequent recall of texts. Results showed that higher levels of crystallized intelligence (as measured by vocabulary scores) were associated with larger wrap-up effects at clause and sentence boundaries, presumably reflecting higher levels of conceptual integration. In addition, higher levels of crystallized intelligence were associated with better recall. Interestingly, older adults who had lower levels of crystallized intelligence seemed to achieve higher levels of recall when they paused more at clause and sentence boundaries, which suggests that wrap-up might be used as a reading strategy to compensate for lower crystallized abilities and promote better understanding of what was read. Although the benefits associated with high levels of crystallized abilities were demonstrated across all texts, high levels of domain knowledge only showed effects for texts specific to the relevant knowledge domain. For these texts, readers with higher levels of knowledge showed larger wrap-up effects compared to readers with lower levels of knowledge.

Older adults' well-preserved crystallized intelligence may be the result of the many more years of reading experience they have accumulated compared to young adults (Mol & Bus, 2011; Stanovich, West, & Harrison, 1995). Indeed, recent work (Payne, Gao, Noh, Anderson, & Stine-Morrow, 2012; Payne, Grison, Gao, Christianson, Morrow, & Stine-Morrow, 2014) has begun to investigate whether

age differences in sentence processing and text memory can be explained at least in part by considering scores on the Author Recognition Test (ART; Acheson, Wells, & MacDonald, 2008; Stanovich & West, 1989) – a checklist of names from which individuals must select the ones they recognize as authors. The ART is a very quick-to-administer paper-and-pencil task, yet it has been shown to be a reliable and valid measure of an individuals' exposure to printed language (Stanovich & West, 1989; West, Stanovich, & Mitchell, 1993), and it shows strong positive correlations with vocabulary knowledge (Beech, 2002; Lewellen, Goldinger, Pisoni, & Greene, 1993; Stanovich et al., 1995), reading comprehension ability (Martin-Chang & Gould, 2008; Stanovich & Cunningham, 1992, 1993), spelling ability (Lewellen et al., 1993; Stanovich & West, 1989), and SAT scores (Hall, Chiarello, & Edmonson, 1996; Lewellen et al., 1993; Stanovich et al., 1995). Despite these strong relationships with other verbal-ability measures, researchers have only recently begun to relate variability in individuals' print exposure to on-line reading patterns (though see Moore & Gordon, 2015).

For example, Payne et al. (2012) found that higher ART scores among older adults were associated with reduced effects of word length and word frequency, slower reading times at clause and sentence boundaries, and better memory for what was read. The authors interpret these findings as supporting the idea that high levels of print exposure result in more efficient lexical processing at the surface level while more resources are allocated to the portions of the sentence where conceptual integration at the textbase level must take place, and that these reading patterns then give rise to successful comprehension and enduring memory representations.

In sum, age-related deficits in sentence processing and text memory tend to emerge at lower levels of representation, such as the surface-level and textbase levels, particularly when sentences are very complex; however, older adults perform as well or better than younger adults when the higher-level situation-model representation of the text is assessed. Further, older adults tend to compensate for their decreased levels of fluid intelligence by drawing on the crystallized intelligence (e.g., knowledge, vocabulary, print exposure) that they have accumulated, which leads to efficient reading strategies that support comprehension and memory. This latter point is largely consistent with the cue-based LTWM framework. That is, the lifetime of reading experience that older adults accrue provides them with a well-organized structure in long-term memory of the patterns that tend to occur in natural language, which older adults can access rapidly and efficiently when they encounter meaningful cues in text that match their stored representations. This perspective is consistent with the notion that sustained engagement in reading throughout the lifespan can continue to enhance the cognitive

architecture that supports the highly skilled processes of language comprehension and text memory.

## Conclusion

Reading is an important life skill in modern, industrialized societies. It plays an important role in economic and other practical activities and in entertainment and understanding of events in the world. This skill is very robust over the adult lifespan because it relies so heavily on the kinds of semantic knowledge that are maintained throughout healthy aging. Research examining word recognition during reading shows that aging does not result in large qualitative differences from the patterns of eye movements seen in younger adults but that aging does lead to systematic changes in a number of ways that are consistent with reduced visual and oculomotor capabilities in combination with greater reliance on knowledge of the patterns of language. Research examining text memory has shown that it is very well preserved with aging as compared to other types of episodic memory. The preservation of text memory in combination with relatively well preserved sentence processing ability supports a shift away from models of working memory in which memory representations that are relevant to processing are temporarily maintained in a resource-intensive way and toward models based on long-term working memory. These newer models focus on how the organization of language allows the creation of highly-structured memory representations that can be accessed effectively, both during and after language processing, using the rich memory retrieval cues that language provides.

## References

- Acheson, D. J., Wells, J. B., & MacDonald, M. C. (2008). New and updated tests of print exposure and reading abilities in college students. *Behavior Research Methods*, 40, 278–289. doi:10.3758/BRM.40.1.278
- Akutsu, H., Legge, G. E., Ross, J. A., & Schuebel, K. J. (1991). Psychophysics of reading-X. effects of age-related changes in vision. *Journal of Gerontology*, 46(6), 325–331. doi:10.1093/geronj/46.6.P325
- Alexander, G. E., Ryan, L., Bowers, D., Foster, T. C., Bizon, J. L., Geldmacher, D. S., & Glisky, E. L. (2012). Characterizing cognitive aging in humans with links to animal models. *Frontiers in Aging Neuroscience*, 4, 1–18. doi:10.3389/fnagi.2012.00021
- Arbuckle, T. Y., Vanderleek, V. F., Harsany, M., & Lapidus, S. (1990). Adult age differences in memory in relation to availability and accessibility of knowledge-based schema. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 16, 305–315. doi:10.1037/0278-7393.16.2.305

- Baddeley, A. D. (1986). *Working memory*. Oxford: Oxford University Press.
- Baddeley, A. D. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Sciences*, 4, 417–423. doi:10.1016/S1364-6613(00)01538-2
- Ball, K. K., Beard, B. L., Roenker, D. L., Miller, R. L., & Griggs, D. S. (1988). Age and visual search: Expanding the useful field of view. *Journal of the Optical Society of America A*, 5(12), 2210–2219. doi:10.1364/JOSAA.5.002210
- Balota, D. A., Watson, J. M., Duchek, J. M., & Ferraro, F. R. (1999). Cross-modal semantic and homograph priming in healthy young, healthy old, and in Alzheimer's disease individuals. *Journal of the International Neuropsychological Society*, 5(07), 626–640. doi:10.1017/S1355617799577060
- Baltes, P. B., & Lindenberger, U. (1997). Emergence of a powerful connection between sensory and cognitive functions across the adult life span: A new window to the study of cognitive aging? *Psychology and Aging*, 12(1), 12–21. doi:10.1037/0882-7974.12.1.12
- Beech, J. R. (2002). Individual differences in mature readers in reading, spelling, and grapheme phoneme conversion. *Current Psychology*, 21, 121–132. doi:10.1007/s12144-002-1008-9
- Beier, M. E., & Ackerman, P. L. (2005). Age, ability and the role of prior knowledge on the acquisition of new domain knowledge. *Psychology and Aging*, 20, 341–355. doi:10.1037/0882-7974.20.2.341
- Borella, E., Ghisletta, P., & de Ribaupierre, A. (2011). Age differences in text processing: The role of working memory, inhibition, and processing speed. *Journal of Gerontology: Psychological Sciences*, 66, 311–320. doi:10.1093/geronb/gbro02
- Bransford, J., & Johnson, M. (1972). Contextual prerequisites for understanding: Some investigations of comprehension and recall. *Journal of Verbal Learning and Verbal Behavior*, 11, 717–726. doi:10.1016/S0022-5371(72)80006-9
- Brysbaert, M., & Vitu, F. (1998). Word skipping: Implications for theories of eye movement control in reading. In G. Underwood (Ed.), *Eye guidance in reading and scene perception* (pp. 125–148). Oxford: Elsevier. doi:10.1016/B978-008043361-5/50007-9
- Brysbaert, M., Drieghe, D., & Vitu, F. (2005). Word skipping: Implications for theories of eye movement control in reading. In G. Underwood (Ed.), *Cognitive processes in eye guidance* (pp. 53–77). Oxford: Oxford University Press. doi:10.1093/acprof:oso/9780198566816.003.0003
- Burke, D. M., & Shafto, M. A. (2008). Language and aging. In F. I. M. Craik & T. A. Salthouse (Eds.), *The handbook of aging and cognition* (3rd ed., pp. 373–443). New York, NY: Psychology Press.
- Burke, D. M., White, H., & Diaz, D. L. (1987). Semantic priming in young and older adults: Evidence for age constancy in automatic and attentional processes. *Journal of Experimental Psychology: Human Perception and Performance*, 13(1), 79–88. doi:10.1037/0096-1523.13.1.79
- Butler, K. M., Zacks, R. T., & Henderson, J. M. (1999). Suppression of reflexive saccades in younger and older adults: Age comparisons on an antisaccade task. *Memory & Cognition*, 27(4), 584–591. doi:10.3758/BF03211552
- Caplan, D., DeDe, G., Waters, G., Michaud, J., & Tripodis, Y. (2011). Effects of age, speed of processing, and working memory on comprehension of sentences with relative clauses. *Psychology and Aging*, 26, 439–450. doi:10.1037/a0021837
- Cassavaugh, N., Kramer, A. F., & Peterson, M. S. (2004). Aging and the strategic control of the fixation offset effect. *Psychology and Aging*, 19(2), 357–361. doi:10.1037/0882-7974.19.2.357
- Cerella, J. (1985). Age-related decline in extrafoveal letter perception. *Journal of Gerontology*, 40(6), 727–736. doi:10.1093/geronj/40.6.727

- Chin, J., Payne, B., Gao, X., Conner-Garcia, T., Graumlich, J. F., Murray, M. D., et al. (2015). Memory and comprehension for health information among older adults: Distinguishing the effects of domain-general and domain-specific knowledge. *Memory* 23, 577–589. doi:10.1080/09658211.2014.912331
- Choi, W., & Gordon, P. C. (2013). Coordination of word recognition and oculomotor control during reading: The role of implicit lexical decisions. *Journal of Experimental Psychology: Human Perception and Performance*, 39(4), 1032–1946. doi:10.1037/a0030432
- Christianson, K., Hollingworth, A., Halliwell, J. F., & Ferreira, F. (2001). Thematic roles assigned along the garden path linger. *Cognitive Psychology*, 42, 368–407. doi:10.1006/cogp.2001.0752
- Christianson, K., Williams, C. C., Zacks, R. T., & Ferreira, F. (2006). Misinterpretations of garden-path sentences by older and younger adults. *Discourse Processes*, 42, 205–238. doi:10.1207/s15326950dp4202\_6
- Craik, F. I. M., & Byrd, M. (1982). Aging and cognitive deficits: The role of attentional resources. In F. I. M. Craik & S. Trehub (Eds.), *Aging and cognitive processes* (pp. 191–211). New York, NY: Plenum Press. doi:10.1007/978-1-4684-4178-9\_11
- Daneman, M., & Carpenter, P. A. (1983). Individual differences in integrating information between and within sentences. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 9, 561–584. doi:10.1037/0278-7393.9.4.561
- Drieghe, D., Rayner, K., & Pollatsek, A. (2005). Eye movements and word skipping during reading revisited. *Journal of Experimental Psychology: Human Perception and Performance*, 31(5), 954–969. doi:10.1037/0096-1523.31.5.954
- Engbert, R., Nuthmann, A., Richter, E. M., & Kliegl, R. (2005). SWIFT: A dynamical model of saccade generation during reading. *Psychological Review*, 112(4), 777–813. doi:10.1037/0033-295X.112.4.777
- Ericsson, K. A., & Kintsch, W. (1995). Long-term working memory. *Psychological Review*, 102, 211–245. doi:10.1037/0033-295X.102.2.211
- Ferreira, F., & Patson, N. (2007). The good enough approach to language comprehension. *Language and Linguistics Compass*, 1, 71–83. doi:10.1111/j.1749-818X.2007.00007.x
- Ferreira, F., Bailey, K. G. D., & Ferraro, V. (2002). Good-enough representations in language comprehension. *Current Directions in Psychological Science*, 11, 11–15. doi:10.1111/1467-8721.00158
- Ferstl, E. C. (2006). Text comprehension in middle aged adults: Is there anything wrong? *Aging, Neuropsychology, and Cognition*, 13, 62–85. doi:10.1080/13825580490904237
- Fozard, J. L., & Gordon-Salant, S. (2001). Changes in vision and hearing with aging. In J. E. Birren & K. Warner Schaie (Eds.), *Handbook of psychology of aging* (pp. 214–266). New York, NY: Academic Press.
- Gordon, P. C., & Lowder, M. W. (2012). Complex sentence processing: A review of theoretical perspectives on the comprehension of relative clauses. *Language and Linguistics Compass*, 6, 403–415. doi:10.1002/lnc3.347
- Gordon, P. C., Hendrick, R., & Johnson, M. (2001). Memory interference during language processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 27, 1411–1423. doi:10.1037/0278-7393.27.6.1411
- Gordon, P. C., Plummer, P., & Choi, W. (2013). See before you jump: Full recognition of parafoveal words precedes skips during reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 39(2), 633–614. doi:10.1037/a0028881

- Haberlandt, K., & Graesser, A. C. (1989). Processing new arguments at clause boundaries. *Memory & Cognition*, 17, 186–193. doi:10.3758/BF03197068
- Haberlandt, K., Graesser, A. C., Schneider, N. J., & Kiely, J. (1986). Effects of task and new arguments on word reading times. *Journal of Memory and Language*, 25, 314–322. doi:10.1016/0749-596X(86)90004-5
- Haegerstrom-Portnoy, G., Schneck, M. E., & Brabyn, J. A. (1999). Seeing into old age: Vision function beyond acuity. *Optometry & Vision Science*, 76(3), 141–158. doi:10.1097/00006324-199903000-00014
- Hale, S., & Myerson, J. (1996). Experimental evidence for differential slowing in the lexical and nonlexical domains. *Aging, Neuropsychology, and Cognition*, 3(2), 154–165. doi:10.1080/13825589608256621
- Hall, V. C., Chiarello, K. S., & Edmonson, B. (1996). Deciding where knowledge comes from depends on where you look. *Journal of Educational Psychology*, 88, 305–313. doi:10.1037/0022-0663.88.2.305
- Hasher, L., Stoltzfus, E. R., Zacks, R. T., & Rypma, B. (1991). Age and inhibition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 17(1), 163–169. doi:10.1037/0278-7393.17.1.163
- Hertzog, C., Dixon, R. A., Hulstsch, D. F., & MacDonald, S. W. S. (2003). Latent change models of adult cognition: Are changes in processing speed and working memory associated with changes in episodic memory? *Psychology and Aging*, 18, 755–769. doi:10.1037/0882-7974.18.4.755
- Hess, T. M., & Flannagan, D. A. (1992). Schema-based retrieval processes in young and older adults. *Journal of Gerontology: Psychological Sciences*, 47, 52–58. doi:10.1093/geronj/47.1.P52
- Hess, T. M., Flannagan, D. A., & Tate, C. S. (1993). Aging and memory for schematically vs. taxonomically organized verbal materials. *Journals of Gerontology*, 48B, P37–P44. doi:10.1093/geronj/48.1.P37
- Inhoff, A. W. (1984). Two stages of word processing during eye fixations in the reading of prose. *Journal of Verbal Learning and Verbal Behavior*, 23(5), 612–624. doi:10.1016/S0022-5371(84)90382-7
- Inhoff, A. W., & Rayner, K. (1986). Parafoveal word processing during eye fixations in reading: Effects of word frequency. *Perception & Psychophysics*, 40(6), 431–439. doi:10.3758/BF03208203
- Ishida, T., & Ikeda, M. (1989). Temporal properties of information extraction in reading studied by a text-mask replacement technique. *Journal of the Optical Society of America A*, 6(10), 1624–1632. doi:10.1364/JOSAA.6.001624
- Johnson, M. L., Lowder, M. W., & Gordon, P. C. (2011). The sentence-composition effect: Processing of complex sentences depends on the configuration of common noun phrases versus unusual noun phrases. *Journal of Experimental Psychology: General*, 140, 707–724. doi:10.1037/a0024333
- Johnson, R. E. (2003). Aging and the remembering of text. *Developmental Review*, 23, 261–346. doi:10.1016/S0273-2297(03)00009-1
- Jordan, T. R., McGowan, V. A., & Paterson, K. B. (2014). Reading with filtered fixations: Adult age differences in the effectiveness of low-level properties of text within central vision. *Psychology and Aging*, 29(2), 229–235. doi:10.1037/a0035948
- Just, M. A., & Carpenter, P. (1980). A theory of reading: From eye fixations to comprehension. *Psychological Review*, 87, 329–354. doi:10.1037/0033-295X.87.4.329

- Just, M. A., & Carpenter, P. A. (1992). A capacity theory of comprehension: Individual differences in working memory. *Psychological Review*, 99, 122–149. doi:10.1037/0033-295X.99.1.122
- Kemper, S. (1987). Syntactic complexity and elderly adults' prose recall. *Experimental Aging Research*, 13, 47–52. doi:10.1080/03610738708259299
- Kemper, S., & Liu, C. (2007). Eye movements of young and older adults during reading. *Psychology and Aging*, 22, 84–93. doi:10.1037/0882-7974.22.1.84
- Kemper, S., Crow, A., & Kemtes, K. (2004). Eye-fixation patterns of high- and low-span young and older adults: Down the garden path and back again. *Psychology and Aging*, 19, 157–170. doi:10.1037/0882-7974.19.1.157
- Kemtes, K. A., & Kemper, S. (1997). Younger and older adults' on-line processing of syntactically ambiguous sentences. *Psychology and Aging*, 12, 362–371. doi:10.1037/0882-7974.12.2.362
- Kennedy, A., Pynte, J., & Ducrot, S. (2002). Parafoveal-on-foveal interactions in word recognition. *The Quarterly Journal of Experimental Psychology: Section A*, 55(4), 1307–1337. doi:10.1080/02724980244000071
- King, J., & Just, M. A. (1991). Individual differences in syntactic processing: The role of working memory. *Journal of Memory and Language*, 30, 580–602. doi:10.1016/0749-596X(91)90027-H
- Kintsch, W. (1988). The role of knowledge in discourse comprehension: A construction-integration model. *Psychological Review*, 95, 163–182. doi:10.1037/0033-295X.95.2.163
- Kintsch, W. (1998). *Comprehension: A paradigm for cognition*. Cambridge: Cambridge University Press.
- Kliegl, R. (2007). Toward a perceptual-span theory of distributed processing in reading: A reply to Rayner, Pollatsek, Drieghe, Slattery, and Reichle (2007). *Journal of Experimental Psychology: General*, 136(3), 530–537. doi:10.1037/0096-3445.136.3.530
- Kliegl, R., Grabner, E., Rolfs, M., & Engbert, R. (2004). Length, frequency, and predictability effects of words on eye movements in reading. *European Journal of Cognitive Psychology*, 16(1–2), 262–284. doi:10.1080/09541440340000213
- Kliegl, R., Nuthmann, A., & Engbert, R. (2006). Tracking the mind during reading: The influence of past, present, and future words on fixation durations. *Journal of Experimental Psychology: General*, 135(1), 12–35. doi:10.1037/0096-3445.135.1.12
- Laubrock, J., Kliegl, R., & Engbert, R. (2006). SWIFT explorations of age differences in eye movements during reading. *Neuroscience & Biobehavioral Reviews*, 30(6), 872–884. doi:10.1016/j.neubiorev.2006.06.013
- Laver, G. D., & Burke, D. M. (1993). Why do semantic priming effects increase in old age? A meta-analysis. *Psychology and Aging*, 8(1), 34–43. doi:10.1037/0882-7974.8.1.34
- Ledoux, K., & Gordon, P. C. (2006). Interruption-similarity effects during discourse processing. *Memory*, 14, 789–803. doi:10.1080/09658210600679915
- Lewellen, M. J., Goldinger, S. D., Pisoni, D. B., & Greene, B. G. (1993). Lexical familiarity and processing efficiency: Individual differences in naming, lexical decision, and semantic categorization. *Journal of Experimental Psychology: General*, 122, 316–330. doi:10.1037/0096-3445.122.3.316
- Lewis, R. L., & Vasishth, S. (2005). An activation-based model of sentence processing as skilled memory retrieval. *Cognitive Science*, 29, 375–419. doi:10.1207/s15516709cog0000\_25
- Lewis, R. L., Vasishth, S., & van Dyke, J. A. (2006). Computational principles of working memory in sentence comprehension. *Trends in Cognitive Sciences*, 10, 447–454. doi:10.1016/j.tics.2006.08.007

- Light, L. L., & Anderson, P. A. (1983). Memory for scripts in young and older adults. *Memory & Cognition*, 11, 435–444. doi:10.3758/BF03196980
- Lima, S. D., Hale, S., & Myerson, J. (1991). How general is general slowing? Evidence from the lexical domain. *Psychology and Aging*, 6(3), 416–425. doi:10.1037/0882-7974.6.3.416
- Lindenberger, U., & Baltes, P. B. (1994). Sensory functioning and intelligence in old age: A strong connection. *Psychology and Aging*, 9(3), 339–355. doi:10.1037/0882-7974.9.3.339
- Martin-Chang, S. L., & Gould, O. N. (2008). Revisiting print exposure: Exploring differential links to vocabulary, comprehension, and reading rate. *Journal of Research in Reading*, 31, 273–284. doi:10.1111/j.1467-9817.2008.00371.x
- McConkie, G. W., & Rayner, K. (1975). The span of the effective stimulus during a fixation in reading. *Perception & Psychophysics*, 17(6), 578–586. doi:10.3758/BF03203972
- McConkie, G. W., & Rayner, K. (1976). Asymmetry of the perceptual span in reading. *Bulletin of the Psychonomic Society*, 8(5), 365–368. doi:10.3758/BF03335168
- McGowan, V. A., White, S. J., Jordan, T. R., & Paterson, K. B. (2014). Aging and the use of interword spaces during reading: Evidence from eye movements. *Psychonomic Bulletin & Review*, 21(3), 740–747. doi:10.3758/s13423-013-0527-8
- Miller, L. M. S. (2009). Age differences in the effects of domain knowledge on reading efficiency. *Psychology and Aging*, 24, 63–74. doi:10.1037/a0014586
- Miller, L. M. S., & Gagne, D. D. (2008). Adult age differences in reading and rereading processes associated with problem solving. *International Journal of Behavioral Development*, 32, 34–45. doi:10.1177/0165025407084050
- Miller, L. M. S., & Stine-Morrow, E. A. L. (1998). Aging and the effects of knowledge on on-line reading strategies. *Journal of Gerontology: Psychological Sciences*, 53B, P223–P233. doi:10.1093/geronb/53B.4.P223
- Miller, L. M. S., Cohen, J. A., & Wingfield, A. (2006). Knowledge reduces demands on working memory during reading. *Memory & Cognition*, 34, 1355–1367. doi:10.3758/BF03193277
- Miller, L. M. S., Stine-Morrow, E. A. L., Kirkorian, H., & Conroy, M. (2004). Adult age differences in knowledge-driven reading. *Journal of Educational Psychology*, 96, 811–821. doi:10.1037/0022-0663.96.4.811
- Mol, S. E., & Bus, A. G. (2011). To read or not to read: A meta-analysis of print exposure from infancy to early adulthood. *Psychological Bulletin*, 137, 267–296. doi:10.1037/a0021890
- Moore, M., & Gordon, P. C. (2015). Reading ability and print exposure: Item response theory analysis of the Author Recognition Test. *Behavior Research Methods*, 47, 1095–1109.
- Morrow, D. G., Leirer, V. O., Andrassy, J. M., Heir, C. M., & Menard, W. E. (1998). The influence of list form and category headings on age differences in understanding medication instructions. *Experimental Aging Research*, 24, 231–256. doi:10.1080/036107398244238
- Myerson, J., Ferraro, F. R., Hale, S., & Lima, S. D. (1992). General slowing in semantic priming and word recognition. *Psychology and Aging*, 7(2), 257–270. doi:10.1037/0882-7974.7.2.257
- Norman, S., Kemper, S., & Kynette, D. (1992). Adults' reading comprehension: Effects of syntactic complexity and working memory. *Journal of Gerontology: Psychological Sciences*, 47, P258–P265. doi:10.1093/geronj/47.4.P258
- Owsley, C. (2011). Aging and vision. *Vision Research*, 51(13), 1610–1622. doi:10.1016/j.visres.2010.10.020
- Paterson, K. B., McGowan, V. A., & Jordan, T. R. (2013a). Filtered text reveals adult age differences in reading: Evidence from eye movements. *Psychology and Aging*, 28(2), 352–364. doi:10.1037/a0030350

- Paterson, K. B., McGowan, V. A., & Jordan, T. R. (2013b). Effects of adult aging on reading filtered text: Evidence from eye movements. *PeerJ*, 1, e63. doi:10.7717/peerj.63
- Payne, B. R., & Stine-Morrow, E. A. L. (2012). Aging, parafoveal preview, and semantic integration in sentence processing: Testing the cognitive workload of wrap-up. *Psychology and Aging*, 27, 638–649. doi:10.1037/a0026540
- Payne, B. R., & Stine-Morrow, E. A. L. (2014). Adult age differences in wrap-up during sentence comprehension: Evidence from ex-Gaussian distributional analyses of reading time. *Psychology and Aging*, 29, 213–228. doi:10.1037/a0036282
- Payne, B. R., Gao, X., Noh, S. R., Anderson, C. J., & Stine-Morrow, E. A. L. (2012). The effects of print exposure on sentence processing and memory among older adults: Evidence for efficiency and reserve. *Aging, Neuropsychology, and Cognition*, 19, 122–149. doi:10.1080/13825585.2011.628376
- Payne, B. R., Grison, S., Gao, X., Christianson, K., Morrow, D. G., & Stine-Morrow, E. A. L. (2014). Aging and individual differences in binding during sentence understanding: Evidence from temporary and global syntactic attachment ambiguities. *Cognition*, 130, 157–173. doi:10.1016/j.cognition.2013.10.005
- Pollatsek, A., Reichle, E. D., & Rayner, K. (2006). Tests of the EZ reader model: Exploring the interface between cognition and eye-movement control. *Cognitive Psychology*, 52(1), 1–56. doi:10.1016/j.cogpsych.2005.06.001
- Radach, R., & Heller, D. (2000). Relations between spatial and temporal aspects of eye movement control. In A. Kennedy, R. Radach, D. Heller & J. Pynte (Eds.), *Reading as a perceptual process*. Amsterdam: Elsevier.
- Radach, R., Kennedy, A., & Rayner, K. (Eds.), 2004. *Eye movements and information processing during reading*. New York, NY: Psychology Press.
- Radvansky, G. A. (1999). Aging, memory, and comprehension. *Current Directions in Psychological Science*, 8, 49–53. doi:10.1111/1467-8721.00012
- Radvansky, G. A., & Copeland, D. E. (2004). Working memory and situation model processing: Language comprehension and memory. *American Journal of Psychology*, 117, 191–213. doi:10.2307/4149022
- Radvansky, G. A., & Copeland, D. E. (2006). Memory retrieval and interference: Working memory issues. *Journal of Memory and Language*, 55, 33–46. doi:10.1016/j.jml.2006.02.001
- Radvansky, G. A., & Copeland, D. E., (2001). Working memory and situation model updating. *Memory & Cognition*, 29, 1073–1080. doi:10.3758/BF03206375
- Radvansky, G. A., & Dijkstra, K. (2007). Aging and situation model processing. *Psychonomic Bulletin & Review*, 14, 1027–1042. doi:10.3758/BF03193088
- Radvansky, G. A., Copeland, D. E., & Zwaan, R. A. (2003). Aging and functional spatial relations in comprehension and memory. *Psychology and Aging*, 18, 161–165. doi:10.1037/0882-7974.18.1.161
- Radvansky, G. A., Copeland, D. E., Berish, D. E., & Dijkstra, K. (2003). Aging and situation model updating. *Aging, Neuropsychology, and Cognition*, 10, 158–166. doi:10.1076/anec.10.2.158.14459
- Radvansky, G. A., Gerard, L. D., Zacks, R. T., & Hasher, L. (1990). Younger and older adults' use of mental models as representations for text materials. *Psychology and Aging*, 5, 209–214. doi:10.1037/0882-7974.5.2.209
- Radvansky, G. A., Zwaan, R. A., Curiel, J. M., & Copeland, D. E. (2001). Situation models and aging. *Psychology and Aging*, 16, 145–160. doi:10.1037/0882-7974.16.1.145

- Ratcliff, R., Thapar, A., Gomez, P., & McKoon, G. (2004). A diffusion model analysis of the effects of aging in the lexical-decision task. *Psychology and Aging, 19*(2), 278–289. doi:10.1037/0882-7974.19.2.278
- Rayner, K. (1975). The perceptual span and peripheral cues in reading. *Cognitive Psychology, 7*(1), 65–81. doi:10.1016/0010-0285(75)90005-5
- Rayner, K. (1978). Eye movements in reading and information processing. *Psychological Bulletin, 85*(3), 618–660. doi:10.1037/0033-2909.85.3.618
- Rayner, K. (1986). Eye movements and the perceptual span in beginning and skilled readers. *Journal of Experimental Child Psychology, 41*, 211–236. doi:10.1016/0022-0965(86)90037-8
- Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin, 124*(3), 372–422. doi:10.1037/0033-2909.124.3.372
- Rayner, K. (2009). Eye movements and attention in reading, scene perception, and visual search. *The Quarterly Journal of Experimental Psychology, 62*(8), 1457–1506. doi:10.1080/17470210902816461
- Rayner, K. (2014). The gaze-contingent moving window in reading: Development and review. *Visual Cognition, 22*(3), 242–258. doi:10.1080/13506285.2013.879084
- Rayner, K., & Bertera, J. H. (1979). Reading without a fovea. *Science, 206*(4417), 468–469. doi:10.1126/science.504987
- Rayner, K., Castelhana, M. S., & Yang, J. (2009). Eye movements and the perceptual span in older and younger readers. *Psychology and Aging, 24*(3), 755–760. doi:10.1037/a0014300
- Rayner, K., Castelhana, M. S., & Yang, J. (2010). Preview benefit during eye fixations in reading for older and younger readers. *Psychology and Aging, 25*(3), 714–718. doi:10.1037/a0019199
- Rayner, K., Inhoff, A. W., Morrison, R. E., Slowiaczek, M. L., & Bertera, J. H. (1981). Masking of foveal and parafoveal vision during eye fixations in reading. *Journal of Experimental Psychology: Human Perception and Performance, 7*(1), 167–179. doi:10.1037/0096-1523.7.1.167
- Rayner, K., Kambe, G., & Duffy, S. A. (2000). The effect of clause wrap-up on eye movements during reading. *The Quarterly Journal of Experimental Psychology A: Human Experimental Psychology, 53*, 1061–1080. doi:10.1080/713755934
- Rayner, K., Pollatsek, A., Drieghe, D., Slattery, T. J., & Reichle, E. D. (2007). Tracking the mind during reading via eye movements: Comments on Kliegl, Nuthmann, and Engbert (2006). *Journal of Experimental Psychology: General, 136*(3), 520–529. doi:10.1037/0096-3445.136.3.520
- Rayner, K., Reichle, E. D., Stroud, M. J., Williams, C. C., & Pollatsek, A. (2006). The effect of word frequency, word predictability, and font difficulty on the eye movements of young and older readers. *Psychology and Aging, 21*(3), 448–465. doi:10.1037/0882-7974.21.3.448
- Rayner, K., Sereno, S. C., Morris, R. K., Schmauder, A. R., & Clifton, C. Jr. (1989). Eye movements and on-line language comprehension processes. *Language and Cognitive Processes, 4*, 21–49. doi:10.1080/01690968908406362
- Rayner, K., Well, A. D., Pollatsek, A., & Bertera, J. H. (1982). The availability of useful information to the right of fixation in reading. *Perception & Psychophysics, 31*, 537–550. doi:10.3758/BF03204186
- Rayner, K., Yang, J., Castelhana, M. S., & Liversedge, S. P. (2011). Eye movements of older and younger readers when reading disappearing text. *Psychology and Aging, 26*(1), 214–223. doi:10.1037/a0021279
- Rayner, K., Yang, J., Schuett, S., & Slattery, T. J. (2013). Eye movements of older and younger readers when reading unspaced text. *Experimental Psychology, 60*(5), 354–361. doi:10.1027/1618-3169/a000207

- Rayner, K., Yang, J., Schuett, S., & Slattery, T. J. (2014). The effect of foveal and parafoveal masks on the eye movements of older and younger readers. *Psychology and Aging*, 29(2), 205–212. doi:10.1037/a0036015
- Reichle, E. D., Pollatsek, A., Fisher, D. L., & Rayner, K. (1998). Toward a model of eye movement control in reading. *Psychological Review*, 105(1), 125–157. doi:10.1037/0033-295X.105.1.125
- Risse, S., & Kliegl, R. (2011). Adult age differences in the perceptual span during reading. *Psychology and Aging*, 26(2), 451–460. doi:10.1037/a0021616
- Salthouse, T. A. (1984). Effects of age and skill in typing. *Journal of Experimental Psychology: General*, 113(3), 345–371. doi:10.1037/0096-3445.113.3.345
- Salthouse, T. A. (1992). Influence of processing speed on adult age differences in working memory. *Acta Psychologica*, 79(2), 155–170. doi:10.1016/0001-6918(92)90030-H
- Salthouse, T. A. (1996). The processing-speed theory of adult age differences in cognition. *Psychological Review*, 103(3), 403–428. doi:10.1037/0033-295X.103.3.403
- Salthouse, T. A. (2009). Decomposing age correlations on neuropsychological and cognitive variables. *Journal of the International Neuropsychological Society*, 15, 650–661. doi:10.1017/S1355617709990385
- Schotter, E. R., Angele, B., & Rayner, K. (2012). Parafoveal processing in reading. *Attention, Perception, & Psychophysics*, 74(1), 5–35. doi:10.3758/s13414-011-0219-2
- Scialfa, C. T., Cordazzo, S., Bubric, K., & Lyon, J. (2013). Aging and visual crowding. *The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*, 68(4), 522–528. doi:10.1093/geronb/gbso86
- Scialfa, C. T., Hamaluk, E., Skaloud, P., & Pratt, J. (1999). Age differences in saccadic averaging. *Psychology and Aging*, 14(4), 695–699. doi:10.1037/0882-7974.14.4.695
- Sekuler, B., Bennett, P. J., Mamelak, M. (2000). Effects of aging on the useful field of view. *Experimental Aging Research*, 26(2), 103–120. doi:10.1080/036107300243588
- Smiler, A. P., Gagne, D. D., & Stine-Morrow, E. A. L. (2003). Aging, memory load, and resource allocation during reading. *Psychology and Aging*, 18, 203–209. doi:10.1037/0882-7974.18.2.203
- Solan, H. A., Feldman, J., & Tujak, L. (1995). Developing visual and reading efficiency in older adults. *Optometry & Vision Science*, 72(2), 139–145. doi:10.1097/00006324-199502000-00012
- Stanovich, K. E., & Cunningham, A. E. (1992). Studying the consequences of literacy within a literate society: The cognitive correlates of print exposure. *Memory & Cognition*, 20, 51–68. doi:10.3758/BF03208254
- Stanovich, K. E., & Cunningham, A. E. (1993). Where does knowledge come from? Specific associations between print exposure and information acquisition. *Journal of Educational Psychology*, 85, 211–229. doi:10.1037/0022-0663.85.2.211
- Stanovich, K. E., & West, R. F. (1989). Exposure to print and orthographic processing. *Reading Research Quarterly*, 24, 402–433. doi:10.2307/747605
- Stanovich, K. E., West, R. F., & Harrison, M. R. (1995). Knowledge growth and maintenance across the life span: The role of print exposure. *Developmental Psychology*, 31, 811–826. doi:10.1037/0012-1649.31.5.811
- Stine, E. A. L. (1990). On-line processing of written text by younger and older adults. *Psychology and Aging*, 5, 68–78. doi:10.1037/0882-7974.5.1.68
- Stine, E. A. L., Cheung, H., & Henderson, D. T. (1995). Adult age differences in the on-line processing of new concepts in discourse. *Aging and Cognition*, 2, 1–18.
- Stine-Morrow, E. A. L., Gagne, D. D., Morrow, D. G., & DeWall, B. H. (2004). Age difference in rereading. *Memory & Cognition*, 32, 696–710. doi:10.3758/BF03195860

- Stine-Morrow, E. A. L., Loveless, M. K., & Soederberg, L. M. (1996). Resource allocation in on-line reading by younger and older adults. *Psychology and Aging*, 11, 475–486. doi:10.1037/0882-7974.11.3.475
- Stine-Morrow, E. A. L., Milinder, L., Pullara, P., & Herman, B. (2001). Patterns of resource allocation are reliable among younger and older readers. *Psychology and Aging*, 16, 69–84. doi:10.1037/0882-7974.16.1.69
- Stine-Morrow, E. A. L., Miller, L. M. S., & Hertzog, C. (2006). Aging and self-regulated language processing. *Psychological Bulletin*, 132, 582–606. doi:10.1037/0033-2909.132.4.582
- Stine-Morrow, E. A. L., Miller, L. M. S., & Leno, R. (2001). Patterns of on-line resource allocation to narrative text by younger and older readers. *Aging, Neuropsychology, and Cognition*, 8, 36–53. doi:10.1076/anec.8.1.36.848
- Stine-Morrow, E. A. L., Miller, L. M. S., Gagne, D. D., & Hertzog, C. (2008). Self-regulated reading in adulthood. *Psychology and Aging*, 23, 131–153. doi:10.1037/0882-7974.23.1.131
- Stine-Morrow, E. A. L., Noh, S. R., & Shake, M. C. (2010). Age differences in the effect of conceptual integration training on resource allocation in sentence processing. *The Quarterly Journal of Experimental Psychology*, 63, 1430–1455. doi:10.1080/17470210903330983
- Stine-Morrow, E. A. L., Ryan, E. A., & Leonard, S. (2000). Age differences in on-line syntactic processing. *Experimental Aging Research*, 26, 315–322. doi:10.1080/0361073000750015714
- Thornton, R., & Light, L. L. (2006). Language comprehension and production in normal aging. In J. E. Birren & K. W. Schaie (Eds.), *Handbook of the psychology of aging* (6th ed.; pp. 262–288). New York, NY: Academic Press.
- Uttl, B. (2002). North American Adult Reading Test: Age norms, reliability, and validity. *Journal of Clinical and Experimental Neuropsychology*, 24(8), 1123–1137. doi:10.1076/jcen.24.8.1123.8375
- van der Linden, M., Hupet, M., Feyereisen, P., Schelstraete, M., Bestgen, Y., Bruyer, R., et al. (1999). Cognitive mediators of age-related differences in language comprehension and verbal memory performance. *Aging, Neuropsychology, and Cognition*, 6, 32–55. doi:10.1076/anec.6.1.32.791
- Van Dyke, J. A., & Lewis, R. L. (2003). Distinguishing effects of structure and decay on attachment and repair: A cue-based parsing account of recovery from misanalyzed ambiguities. *Journal of Memory and Language*, 49, 285–316. doi:10.1016/S0749-596X(03)00081-0
- Verhaegen, C., & Poncelet, M. (2013). Changes in naming and semantic abilities with aging from 50 to 90 years. *Journal of the International Neuropsychological Society*, 19(02), 119–126. doi:10.1017/S1355617712001178
- Verhaeghen, P. (2003). Aging and vocabulary score: A meta-analysis. *Psychology and Aging*, 18(2), 332–339. doi:10.1037/0882-7974.18.2.332
- Verhaeghen, P., & Cerella, J. (2002). Aging, executive control, and attention: A review of meta-analyses. *Neuroscience & Biobehavioral Reviews*, 26(7), 849–857. doi:10.1016/S0149-7634(02)00071-4
- Verhaeghen, P., Cerella, J., Semene, S. C., Leo, M. A., Bopp, K. L., & Steitz, D. W. (2002). Cognitive efficiency modes in old age: Performance on sequential and coordinative verbal and visuospatial tasks. *Psychology and Aging*, 17(4), 558. doi:10.1037/0882-7974.17.4.558
- Vitu, F., McConkie, G. W., Kerr, P., & O'Regan, J. K. (2001). Fixation location effects on fixation durations during reading: An inverted optimal viewing position effect. *Vision Research*, 41(25), 3513–3533. doi:10.1016/S0042-6989(01)00166-3
- West, R. F., Stanovich, K. E., & Mitchell, H. R. (1993). Reading in the real world and its correlates. *Reading Research Quarterly*, 28, 35–50. doi:10.2307/747815

- White, S. J., Rayner, K., & Liversedge, S. P. (2005). The influence of parafoveal word length and contextual constraint on fixation durations and word skipping in reading. *Psychonomic Bulletin & Review*, 12(3), 466–471. doi:10.3758/BF03193789
- Wotschack, C., & Kliegl, R. (2013). Reading strategy modulates parafoveal-on-foveal effects insentence reading. *The Quarterly Journal of Experimental Psychology*, 66(3), 548–562. doi:10.1080/17470218.2011.625094
- Zelinski, E. M., & Kennison, R. F. (2007). Not your parents' test scores: Cohort reduces psychometric aging effects. *Psychology and Aging*, 22, 546–555. doi:10.1037/0882-7974.22.3.546



## Cognitive and linguistic processes among oldest old persons

Heterogeneity, methodological challenges,  
and relevance of psychosocial resources

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Cognitive and linguistic abilities are synergistic, working together to support functioning and quality of life throughout the lifespan, including very old age. Unfortunately, understanding of cognitive development and change amongst the oldest old is lacking due in part to assessment challenges (e.g., sensory impairment and fatigue, measure equivalence) and study paucity. These limitations hamper attempts to distinguish typical age-related decline from non-normative change and identify factors related to impairment and resilience. For individuals in very late life current psychosocial resources and events, as well as conditions of childhood and early life, impact functioning. These psychosocial influences play a role in adaptation and subsequent developmental outcomes. In this chapter, we focus on three later-life themes as they relate to cognitive and linguistic processes including heterogeneity in advanced age and diversity of outcomes, methodological challenges, and role of psychosocial resources and context.

Recent generational increases in life expectancy and the coming of age among baby boomers have prompted recognition of the impact that an aging demographic has on all aspects of society. One subgroup of particular interest is those adults living to very old age. These persons, designated as the “oldest old,” proportionately represent the fastest growing segment of the population and an increasingly larger sector of the 65+ population (He & Muenchrath, 2011). In the 1980s, this group was identified as being aged 85 and older (Suzman & Riley, 1985); however, due to their rapid growth and potentially different abilities and

needs, the designation was recently changed to 90 years of age and older (He & Muenchrath, 2011).

The oldest old population includes centenarians, or individuals reaching 100 years of age. The odds of achieving centenarian status have increased from a near impossibility at one time to “1 in 50 for females in low-mortality nations” (National Institute on Aging, 2011); thus, this milestone in human history is becoming a more familiar feat. To put this point in perspective, current centenarians successfully doubled their expected life expectancy (i.e., 47.3 years average collapsed across sex and ethnicity; Shrestha, 2005). In contrast, children born in 2009 across developed countries have a significant advantage in the quest for longevity and survival into very late life, with a projected average life expectancy of 79.5 years (Organisation for Economic Co-operation and Development, 2011).

The impact of growth among the oldest old can be felt at multiple levels. For individuals, new approaches to education and career preparation, as well as financial, retirement, and care planning are issues of utmost concern given the historic increase in life expectancy. For families, four generation structures will be increasingly more common (Bengtson, 2001) and the nature of caregiving across generations may be elongated with care of older family members starting when caregivers are older adults themselves (Suitor, Sechrist, Gilligan, & Pillemer, 2011). Growth among the oldest old prompts unique care challenges at broader community and societal levels and necessitates economic and policy implications related to health, families, and work. A key component to health and well-being in very late life is cognitive ability. In this chapter, we highlight three later-life themes as they relate to cognitive and linguistic processes including heterogeneity in advanced age and diversity of outcomes, challenges to later life assessment, and the role of psychosocial resources and context.

### **Heterogeneity, change, and diversity among the oldest old: Impact on daily life**

As we consider the oldest old, it is prudent to also consider the impact of heterogeneity, change, and diversity of outcomes in relation to cognition. The first issue, heterogeneity, concerns a group-level phenomenon – namely who is counted among the “old” and the degree of similarity and dissimilarity within this group. The second and third issues center on what happens in older age. At the individual level, the oldest old exhibit developmental changes (some normative/expected and some not) and a diversity of cognitive outcomes. In the following section we discuss the effects of cohort, time, and development on cognitive aging in later life and their impact on day-to-day functioning.

## Heterogeneity within “old age”

For clinicians and other providers, researchers, businesses, and policy makers it is important to recognize the heterogeneity which exists within the group identified as “older adults.” This group is not a homogeneous group in many respects. Perhaps most notably, older adulthood represents an age span of decades (i.e., 60–100+) and is composed of individuals from multiple cohorts or generations who have been affected by varying events. As a result, history and cohort influences affect cognitive ability development and manifestation across the life course (Schaie, 2012). Currently included among those 65 and older are three generational or “cohort” distinctions. The “Greatest Generation” is said to include the subgenerations dubbed the GI Generation (birth years 1901–1924) and the Silent Generation (birth years 1925–1945). The third generational distinction consists of the baby boomers (birth years 1946–1964). Older adults within these generations experienced events at differing ages – or for the youngest generation, not at all. For example, baby boomers were born after the Great Depression and World War II.

Cohort effects impact cognitive-linguistic development and performance in later life in profound ways via mechanisms such as education (e.g., prevailing pedagogical approach, attainment potential) and health (e.g., specific morbidity rates, average life expectancy). There is suggestion of successive generational gains in selected measures of cognitive performance in some developed countries (i.e., Flynn effect; Flynn, 1987). However, this interpretation has been contested and any generational gains may be faltering (Flynn, 2007; Schaie, Willis, & Pennak, 2005).

In addition to generational effects, historical or time-related events affect functioning for subsequent cohorts and not always in positive ways. For instance, Schaie (1996) hypothesized that observed cohort declines in numeric ability (e.g., mental math) might be attributable to the introduction of the handheld calculator. Current culture and language appear to be changing even more rapidly (e.g., use of emerging words not found in the dictionary, adoption of novel inventions; Michel et al., 2011). Technology will continue to affect aspects of work, leisure and family life and will undoubtedly shape future generations of older adults. Thus, the effects of technology on cognitive and linguistic skills thus continue to evolve and we will need to grapple with issues of differential technological access, efficacy, and impact (e.g., Satariano, Scharlach, & Lindeman, 2014).

Finally, as we consider “who” is aging, we need to acknowledge the varied backgrounds, experiences, resources, and interests people bring with them to older age which result in a wide range of preferences, functional abilities, and capabilities. In short, older age is accompanied by increased heterogeneity and this diversity is

particularly relevant to our consideration of the oldest old (e.g., Von Humboldt & Leal, 2015; Sadana, Foebel, Williams, & Beard, 2013). Augmenting these individual differences will be increasing cultural differences. For instance, we can expect to observe more ethnic heterogeneity following the baby boomers (Colby & Ortman, 2014) – a change which will likely affect many aspects of older adult development. Keeping in mind these macro-level influences, we move next to a discussion of what happens during later life cognitive aging at the individual level.

### Developmental changes and diversity of cognitive outcomes among the oldest old

Cognition is a broad construct and it is useful to distinguish its components. This is especially pertinent to our discussion of the oldest old given the great diversity of functioning and outcomes and subsequent need to adjust our assessments and conceptualizations accordingly. In particular, it is important to differentiate functioning, aging, health, and vitality within the context of cognition (Margrett, Mast, Isales, Poon, & Cohen-Mansfield, 2011; Poon, Rubin, & Wilson, 1989). As described by Margrett et al. (2011), cognitive *functioning* refers to an individual's observed performance across specific abilities such as prospective memory, verbal comprehension, and inductive reasoning. "Cognitive *aging*" refers to typical or normative age-related change in functional performance such as slower processing speed with increased age. In contrast, non-normative changes in cognitive functioning such as dementia are atypical and not considered inevitable consequences of development and aging. Consideration of cognitive aging helps us to understand a pattern of functional observations, comparing performance to others (e.g., norms) and putting them in a lifespan context. Cognitive *health* represents the aggregate of ability functioning – ranging from no impairment to mild and severe impairment – and helps delineate the outcomes of cognition.

Numerous scales exist to assess cognitive status, which is commonly also referred to as mental status. Screening tools such as the Mini-Mental State Examination (MMSE; Folstein & Folstein, & McHugh, 1975) are used to measure selected dimensions of basic cognitive functioning and determine whether impairment is likely. Other tools are available to assess the degree of functioning and impairment in the case of dementia (e.g., Clinical Dementia Rating; CDR; Morris, 1993) and it is common practice to augment the MMSE with other measures (Bak & Moishi, 2007). Across all levels of cognitive health, oldest old individuals may exhibit varying degrees of cognitive *vitality* or successful application of cognitive skills to one's environment (Margrett et al., 2011). This point is particularly

important as relative success and optimization are achievable even within the context of dementia (e.g., Cohen-Mansfield, Pappura-Gill, & Golander, 2006).

Language processing and linguistic ability consist of processes related to speech production and comprehension and metalinguistic awareness and aptitude. Although there are distinct aspects of cognitive and linguistic abilities, it is important to recognize their synergy. Glisky (2007) defines linguistic ability as a “higher-level cognitive function.” Requisite cognitive functioning is needed to facilitate linguistic ability. Language involves interactions between the phonological and semantic systems (Burke & Shafto, 2008) in which cognitive abilities such as long-term memory and sequencing/reasoning are at work. Linguistic and cognitive functioning likely rely on some of the same systemic processes, including perceptual-motor speed, attention, and working memory as well as adequate sensory functioning and resources such as mental energy (Burke & Shafto), each of which becomes more challenged in advanced age.

The connection between cognitive functioning and linguistics is very apparent amongst oldest old persons. Reversible and non-reversible dementias (Poon, Crook, Eisdorfer, Guland, Kaszniak & Thompson, 1986) significantly impact everyday cognition and linguistic processing and there is an observed language break down during the progression of dementia. Kertesz et al. (2010) describe a particular type of dementia, semantic dementia, which presents behavioral symptoms and language deficits distinct from other dementias. Further investigation is needed to explore the synergistic effects of cognition and language throughout the lifespan as related to risk and resilience. For instance, a study by Iacono and colleagues (2009) illustrates the relationship between cognitive and linguistic abilities across the life course. Their findings suggested a positive association between participants’ written linguistic “idea density” as an emerging adult and preserved cognitive functioning in later life – even in the face of underlying brain pathology (i.e., lesions indicative of Alzheimer’s disease).

### Normative cognitive changes in adulthood

Although numerous conceptual and empirical challenges are present when developing, validating and interpreting normative data for the oldest old, some generalizations can be made. Two questions of primary interest center on (1) the nature of development and change across cognitive abilities; and (2) when age-related cognitive changes occur. To address the first question, prior work has differentiated two broad classes of cognitive abilities composed of several individual skills, and this distinction appears to remain important through very late life (Hagberg, Alfredson, Poon, & Homma, 2001). Crystallized abilities are those that rely on

accumulated knowledge and experience and are highly dependent upon an individual's culture. A prime example of such an ability is verbal comprehension. In contrast, fluid abilities are those intellectual skills that are considered more "innate" and biologically driven. Often, fluid abilities focus on the ability to navigate novel situations and to solve new problems. Fluid abilities include skills such as memory and inductive reasoning.

Empirical studies support the distinctiveness of these two classes of abilities as well as demonstrate differential performance ranges and trajectories across adulthood. Within-person (i.e., intra-individual) age-related changes are well documented (e.g., Schaie, 1996, 2005, 2012). With accumulated experience, crystallized abilities tend to demonstrate an increase through middle age, and these skills are generally maintained well into the seventies. In age comparative studies, older adults generally fare better than or as well as younger adults on crystallized assessments. On the other hand, fluid abilities peak in the early twenties and exhibit a gradual decline throughout adulthood. Thus, younger adults tend to outperform older adults on assessments of fluid tasks. Relevant to very late life, Hagberg and colleagues (2001) describe data from centenarians that conform to these patterns. Centenarians demonstrate a greater range of performance on measures of crystallized abilities whereas performance on fluid measures tended to be more similar, suggesting a floor effect.

Further impediments include limited studies of later life cognitive abilities and even fewer longitudinal investigations. Accelerated decline is common in later life and even a brief interval between assessments can have an enormous impact at this age. In particular, a developmental phenomenon of relevance to later life is precipitous cognitive decline evident as older adults approach death. Numerous studies illustrate terminal cognitive decline (evident approximately 3 years prior to death) and drop (evident within one year of death; see Bäckman, Small, & Wahlin, 2001; Berg, 1996). Other work suggests a synergy between age and "pathology burden" on cognitive decline (e.g., Rabbitt, Lunn, Pendleton, & Yardefagar, 2011).

In light of its population-based sampling approach, the Georgia Centenarian Study has published normative data for a variety of cognitive measures used in the study. For example, Miller et al. (2010) published unweighted and population-weighted normative data based on 244 centenarians aged 98–107 and 80 octogenarians for the Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975), the Severe Impairment Battery (Saxton et al., 1990), and the Behavioral Dyscontrol Scale (Grigsby & Kaye, 1996). Centenarian performance was stratified into three age cohorts (98–99, 100–101, and 102–107). Centenarian performance on these measures was substantially different than the performance of the octogenarian sample (80–90 years of age). Furthermore, even among the age cohorts

in the centenarian group, cognitive performance differed substantially for each group. This finding highlights the substantial impact of even small changes in age on cognitive functioning among the oldest old.

Mitchell et al. (2013) published an additional set of normative data for more specific measures of verbal abstract reasoning (WAIS-III Similarities subtest), verbal fluency (Controlled Oral Word Association Test, Benton & des Hamsher, 1976), memory (Fuld, 1977), and motor functioning using data from Phase III of the Georgia Centenarian Study. Consistent with previous literature, these normative data suggest that tasks that are speeded in nature or that tap fluid abilities show less variability with increasing age, as centenarians approach a floor level of performance (Hagberg et al., 2001).

Lastly, Rahman-Filipiak et al. (2014) presented normative data for performance measures on the Fuld Object Memory Evaluation (FOME; Fuld, 1977) using data from the Georgia Centenarian Study. As with our previous normative publications, octogenarians outperformed centenarians on all performance indices. Within the three age strata for centenarians, small increases in age related to substantial performance differences on the majority of performance indices. In addition, the FOME uses several study-test trials to investigate learning and memory. However, in this study, neither octogenarians nor centenarians showed a benefit of repeated exposure to the test material after the second learning trial. This finding raises the possibility that this test could be abbreviated to two learning trials in persons aged 80 years and older for efficiency and practical considerations.

### Non-normative cognitive changes in adulthood

Changes such as occasionally forgetting the names of acquaintances or slower processing speed with increased age are considered normative. In contrast, forgetting the names of loved ones or the names of objects is considered non-normative and an indicator of pathology-related impairment. A group of conditions distinguishable from normal cognitive aging has been identified. Mild cognitive impairment (MCI) reflects memory impairment that does not interfere with activities of daily living, whereas dementia affects more cognitive abilities than memory (e.g., difficulties with language, orientation to time and place, problem solving) and interferes with day-to-day functioning (American Academy of Neurology, n.d.). Conversion of MCI to dementia is estimated at 6–25% (American Academy of Neurology). In addition, recent clinical and empirical work has been devoted to characterizing “cognitive frailty,” a condition in which physical frailty and cognitive impairment co-occur with the absence of a diagnosis of dementia (Kelaiditi

et al., 2013). Use of this designation may highlight at-risk individuals (particularly among the oldest old) and lead to intervention targets (Kelaiditi et al.); however, further investigation and refinement is needed (e.g., Canevelli, Cesari, & van Kan, 2015).

Difficulties arise related to assessment of non-normative cognitive change. A chief difficulty detailed by Perls (2004b) and Poon et al. (2012) is the estimated prevalence of dementia in advanced age that varies significantly between national and cross-national samples. The discrepancies in prevalence rates across studies may reflect underlying population differences yet to be determined or simply sampling and methodological differences. Sample selectivity is an issue as individuals with certain diseases and dementia may have died at earlier ages, thereby resulting in a selective later life sample (Perls, 2004a). Prevalence differences may result from study differences in assessment tools and criteria used to determine impairment as well as failing to account for characteristics such as sex, ethnicity, education, and residence at home or a care facility (Poon et al.).

There is general consensus that the risk of dementia does increase with age (American Academy of Neurology, n.d.). However, despite varied estimates and popular perceptions, dementia is not considered an eventuality of later life and dementia among centenarians is not inevitable (Andersen-Ranberg, Vasegaard, & Jeune, 2001). Very old individuals, and centenarians in particular, “are of scientific interest as a human model of relative resistance to dementia (Perls, 2004b, p. 1587).” In a review of cross-national studies investigating cognitive functioning and dementia among the oldest old, Perls notes that some very old individuals appear to delay the onset of dementia until very late life (thereby compressing the duration and functional limitations imposed by the disease) and others may employ “adaptive capacity” or “functional reserve” in staving off behavioral deficits typically resulting from underlying neuropathology (see Table 2). Further research is needed to investigate whether these cases represent “resilience” to Alzheimer’s disease (AD; Negash et al., 2013) or a prodromal state (Driscoll & Troncoso, 2011). The possibility of the former raises many questions about protective factors, a point we will revisit.

## Language and aging

The development and expression of cognitive and linguistic abilities are interrelated and this relationship becomes more pronounced in later life when normative age-related cognitive changes and potential acceleration in decline occur. Differing hypotheses exist regarding the mechanisms underlying cognitive aging and as a consequence, several age-related cognitive changes could explain changes in language in older adulthood (Burke & Shafto, 2008). Linguistic aging may reflect

underlying declines in: mental resources and energy, processing speed, working memory, ability to inhibit irrelevant information, and neural and mental connections (Burke & Shafto). As mentioned previously, verbal comprehension is thought to be an example of a “crystallized” ability which tends to strengthen during adulthood and remain strong until very late life. However, some changes in language do occur. A commonly cited problem during older age is called “tip-of-the-tongue phenomenon.” In this case, an individual is thinking of a word, but just not able to verbalize it (Schwartz & Brown, 2014; see also Chapter 2). Other work suggests normative changes including decline in grammatical complexity and propositional content (“idea density”) after age seventy (Kemper, Thompson, & Marquis, 2001). As a result, cognitive aging can exacerbate changes in language and in the case of cognitive impairment, is even more deleterious to communication.

In the case of non-normative cognitive changes such as dementia, linguistic abilities can become severely compromised. For instance, Kemper and colleagues (2001) observed accelerated change in grammatical complexity and idea density among persons with Alzheimer’s disease irrespective of age. Aphasia is an example of a non-normative change in linguistic skills in which an individual has difficulty using words and symbols as the result of brain damage such as stroke and dementia (Lesser & Milroy, 1993). Individuals experiencing different types of aphasia vary in language fluency and comprehension. Approximately 1 million Americans are affected by aphasia, most of whom are middle-aged or older adults (National Institute on Deafness and Other Communication Disorders, n.d.).

Contributing to both language and cognitive difficulties in older age are deficiencies in sensory and perceptual inputs. Risk of hearing loss increases with age and the National Institute on Deafness and other Communication Disorders (NIDCD, n.d.) reports the “disabling hearing loss” prevalence to be 25% among persons aged 65 to 74 and 50% among individuals aged 75 and older. Unfortunately the majority of adults with hearing loss aged seventy and older do not use hearing aids (NIDCD, n.d.) and hearing loss is associated with increased risk of cognitive impairment (e.g., Lin et al., 2013).

### **Individual differences: Diversity of outcomes in later life**

Development across the lifespan is represented by both gains and losses and although more losses are evident during older adulthood (Baltes, Ebner, & Freund, 2006), later life cannot be characterized only by decline. A prime example of this principle is work by Evert and colleagues (2003) examining later life health outcomes. The researchers identified three distinct later life profiles among centenarians in the New England Centenarian Study based on common morbidities

including “hypertension, heart disease, diabetes, stroke, nonskin cancer, skin cancer, osteoporosis, thyroid condition, Parkinson’s disease, and chronic obstructive pulmonary disease” (Evert, Lawler, Bogan, & Perls, 2003). As would be expected, a fair proportion of centenarians (i.e., 24% of the males, 43% of the females) in their sample had “survived” a major disease diagnosis prior to age eighty. Important to note, however, is the fact that many of the centenarians sampled had “delayed” diagnosis until after age eighty (i.e., 44% of males, 42% of females) and a significant proportion had “escaped” diagnosis all together (i.e., 32% of males, 15% of females). In an analogous study of centenarians in Georgia, Arnold et al. (2010) reported that centenarians could be divided into similar categories: survivors (i.e., diagnosis before age 80; 43%), delayers (i.e., diagnosis between 80 and 98 years of age; 36%) and escapers (i.e., diagnosis at 98 or older; 17%). Arnold et al. then compared the proportion of centenarians within each category for two chief morbidities. The findings indicated that centenarians diagnosed with cancer were more likely “escapers,” whereas those diagnosed with cardiovascular diseases could be characterized as survivors, delayers, or escapers. These results replicated the finding that cancer shortens lives (i.e., persons with cancer did not survive to be centenarians) and medical interventions have advanced to a point that individuals with cardiovascular diseases could live to a ripe old age.

In a similar fashion, cognition in later life is not entirely indicative of deterioration as might be presumed. Diversity is observed even at very advanced ages. In two studies of centenarians, Kliegel et al. (Heidelberg Centenarian Study; Kliegel, Moor, & Rott, 2004) and Margrett et al. (Iowa Centenarian Study; Margrett, Hsieh, Heinz, & Martin, 2012) identified patterns of longitudinal change in cognitive status reflecting distinct outcomes including patterns indicative of impairment and decline, as well as stability, enhanced performance, and variability in performance across time. Together, these studies illustrate the diversity of important functional outcomes among the oldest old. In addition, they also serve to highlight the fact that development and change in later life may reflect not only decline, but also stability, changing, and enhanced functioning.

### Transition from normative to non-normative cognition

Cognitive impairment and dementia significantly impact older adults, with the highest prevalence rates evident among oldest old individuals – potentially as high as one in two individuals. Given the increased prevalence among oldest old individuals, investigating the continuity and change of influential factors in the prediction of both adaptation and impairment across the lifespan is vital. It is not clear to what extent behavioral markers or precursors may be evident during the transition from normative to non-normative cognition. One avenue for research has been

examination of cognitive variability (i.e., deviation from an individual's typical performance range). Recent investigations have focused on biomarker evidence which may be detectable years prior to behavioral indications (for discussions see Ewers, Sperling, Klunk, Weiner, & Hampel, 2011 and Sperling et al., 2011). It is clear that great need exists for prospective studies which include varied assessments (e.g., clinical examination, functional imaging) and postmortem data.

### Cognitive and linguistics contributions to everyday functioning during later life

Cognitive and linguistic abilities exert a profound impact on the day-to-day life of older adults, particularly when challenges are encountered and compensatory mechanisms falter. Declining cognitive and linguistic skills can be particularly problematic for the oldest old who are also more likely to face multiple challenges across domains (e.g., physical health, sensory functioning) and possess fewer psychological and social resources (e.g., Martin, Poon, Kim, & Johnson, 1996).

As outlined by Kang and Russ (2009), wellness can be characterized as including aspects of “physical, emotional, spiritual, intellectual, occupational, and social” activities and well-being. Linguistic ability is vital to optimal aging – particularly interactions with others and understanding of context. As described by Burke and Shafto (2008), deterioration in language comprehension and production can “undermine older adults’ ability and desire to communicate, and can erode evaluation of their language competence by themselves and others (p. 373).” As a result, harmful effects may include “negative self-appraisal [which] promotes withdrawal from social interaction, and negative appraisal by others [which] promotes their use of oversimplified speech to older adults (p. 373).” Cognitive and linguistic abilities work in tandem with and support other domains of whole-person wellness in older adulthood, thereby contributing to “successful” or “optimal” aging. A prime illustration is the seminal work of Rowe and Kahn (1997) who included “maintenance of high physical and cognitive functioning” as one of their three components of successful aging, along with “avoidance of disease and disability” and “sustained engagement in social and productive activities.” Maintaining these components of successful aging becomes increasingly difficult in very old age (Cho, Martin, & Poon, 2012; Martin et al., 2015).

From a practical standpoint, cognitive-linguistic abilities form the foundation for many critical actions needed to navigate everyday life. For instance, prospective memory enables us to remember important events (e.g., a doctor's appointments, morning medication) and tasks (e.g., turn off the stove). Instrumental activities of daily living such as financial management, meal preparation, and transportation are accomplished using a compilation of cognitive processes

including memory and “complex reasoning” (Pernecky et al., 2006). Willis (1996) defined “everyday cognitive competence” as “the ability to perform adequately those cognitively complex tasks considered essential for living on one’s own in this society” (p. 595). Indeed, among community-dwelling older adults, an early indicator of cognitive impairment is often inability to manage more advanced instrumental activities of daily living (IADL; e.g., shopping and finances) as compared to lower-level skills ADLs such as bathing and maintaining personal hygiene (e.g., Ahn et al., 2009; Njegovan, Man-Son-Hing, Mitchell, & Molnar, 2001). Deficits in cognitive abilities result in impairment and inability to age in place. Dementia is related to increased caregiver burden (e.g., Kim, Chang, Rose, & Kim, 2012) and is cited as the most prevalent reason for placement in long-term care settings (e.g., Zimmerman et al., 2002).

Cognitive and linguistics skills are vital to communication, relationships, and problem solving. Older adults lacking in these skills can be subject to scam, neglect, and abuse (e.g., Bonnie & Wallace, 2002; Laumann et al., 2008). In summary, quality of life, independence, and the ability to navigate everyday life rely upon one’s cognitive and linguistic abilities.

### **Methodological challenges assessing cognitive change among the oldest old**

Developmental increases and declines across the lifespan make normative data important for (a) characterizing the types of changes that are expected and unexpected at specific ages and (b) identifying longer-term processes at work (e.g., transition to impairment). Given the diversity of later life outcomes and measurement challenges, characterizing the bounds of “typical” change is difficult and a major obstacle to the study of cognitive aging is lack of norms for very advanced ages. Investigation of cognition and accelerated change and their determinants among the oldest old can provide insights into lifespan factors leading to risk and resilience.

It is noteworthy that the normative data for the Wechsler Adult Intelligence Test-Revised (WAIS-R) extended only to 74 years of age (Wechsler, 1981). Nevertheless, clinical evaluations were routinely requested for persons whose age exceeded that upper normative limit, making the objective determination of an expected level of performance in this age range quite difficult. It was not until 1997 that the third revision of the Wechsler Adult Intelligence Scale provided normative data for persons up to 89 years of age (Wechsler, 1997). Recently Miller and colleagues (Miller, Mitchell, Woodard, Davey, Martin, & Poon, 2010) provided

comprehensive norms of cognitive performances from the Georgia Centenarian Study that illustrated the range and variability in cognitive performances of the oldest old. As the population of older adults continues to grow exponentially, normative data become increasingly important for understanding capabilities and needs in late life. For example, it is not known whether or to what extent specific cognitive abilities change in a linear or non-linear fashion among the oldest old. Furthermore, because dementia prevalence increases with age, the extent to which relative performance on specific cognitive measures may indicate the onset of cognitive decline in this age range is also not known.

Several challenges to cognitive assessment among the oldest old contribute to the scarcity of cognitive data from the oldest old, lack of norms, and potential misinterpretation of performance (see Table 1). One major challenge is *sampling* (Poon & Perls, 2007) including both initial and ongoing selectivity. As noted by Schaie (2005), attrition and selectivity pose theoretical and practical (e.g., small cell size) problems to the long-term investigation of cognition and functioning. It can be difficult to identify and recruit oldest old individuals and some avenues for identification may result in bias. For instance, the Iowa Centenarian Study utilized a list kept by the state to identify centenarians eligible to participate (Martin,

**Table 1.** Developmental and methodological considerations and challenges associated with later life cognitive performance and assessment

<b>Developmental &amp; contextual</b>
Sensory impairment effects on cognitive performance and assessment
Heterogeneity of “older adults” as a group
Increased diversity of functioning with age
Accelerated decline and increased dementia prevalence rates with age
Group differences (e.g., sex, socioeconomic resources, ethnicity, culture)
Focus on intra- or inter-individual performance
Cohort and time effects (e.g., educational attainment increases)
Need for life-span perspective
Differential nature and importance of antecedents and consequences over time
<b>Measurement &amp; interpretation</b>
Sampling bias (i.e., initial, survivorship, and attrition)
Task or skill domain specificity (e.g., working memory) versus generalization (e.g., mental status)
Scoring procedure variation (e.g., fluency versus efficiency)
Differential reporting across data sources (e.g., self-report, proxy-report, performance)
Measurement equivalence within individuals and across groups
Criteria to assess dementia
Criteria for comparison, “success,” or vitality

Margrett, & Lockhart, in press). All long-term care facilities in Iowa are asked to contribute yearly to the list. In contrast, compilation of community-dwelling centenarians' information is less systematic and thus, centenarians living in long-term care facilities are more likely to be over represented. Attrition and missing data due to mortality, frailty, and fatigue pose challenges to study of this population.

A second issue centers on *requirements of the task*. Certain cognitive measures that may be appropriate for individuals under 80 years of age may prove to be overly taxing or challenging for the oldest old. As a result, testing batteries are selective and may involve a proxy reporter. Sensory and motor impairments and deficits also affect testing of the oldest old. The prevalence of vision and hearing impairment approximately doubles in the oldest old relative to persons aged 65–74 years of age (US Census, 2010), and approximately 25% of the oldest old have extremity impairment that may affect performance on sensorimotor tasks (Dillon, Gu, Hoffman, & Ko, 2010). For example, assessments such as the Mini-Mental State Exam (Folstein, Folstein, & McHugh, 1975) which include items relying on sensory and motor skills (e.g., copying a figure) can be difficult or impossible for oldest old individuals to complete and result in missing items or a reduced score if not adjusted (see Holtsberg et al., 1995). Thus, because most normative datasets do not take into account differential levels of sensory acuity, sensory and motor impairments, and sensory and cross-modal processing across the lifespan, age-specific normative data can be particularly valuable (e.g., Baldwin & Ash, 2011; Dillon, Gu, Hoffman, & Ko, 2010; Setti et al., 2011).

Alternative sources of information may be required in the case of fatigue, communication difficulties, and cognitive impairment. Unfortunately, self-reports, proxy-reports, performance-based, and observational indicators can vary in their veridicality and may not be analogous. For instance, in the Seattle Longitudinal Study a substantial proportion of participants themselves were not accurate assessors of their own cognitive change (i.e., pessimists, optimists; Schaie, 2005). Other later life investigations comparing sources of information reflect both differences and similarities across sources. Martin, da Rosa, Siegler, Davey, MacDonald, and Poon (2006) investigated self- and proxy-ratings of personality among centenarians. Study findings revealed mean differences between self- and proxy-ratings, but the rank order of targets remained consistent between data sources. MacDonald, Martin, Margrett, and Poon (2009) examined concordance of self-, proxy-, and observer ratings of centenarians' mental health and predictors of those ratings. The results indicated that average ratings did not vary across source. In terms of predicting ratings, there were common predictors between each pairing. However, most predictors did vary by source.

Prior research suggests that each source is differentially biased based on individual and contextual differences and perceptions depend on the domain (i.e.,

cognitive performance versus subjective health). For instance, older adults generally tend to view their subjective well-being quite positively despite objective change and loss, a perspective likely related to health and survival (Diener & Chan, 2011) and impacted by many factors (George, 2011). Thus, the characteristics of the individual (e.g., efficacy, locus of control) and coping mechanisms (e.g., social comparison, accommodation) employed will impact subjective reports. Proxies can provide valuable information, particularly regarding targets in very late life who may not be able to supply information to researchers. However, the information available to proxies will vary depending on several factors including: (1) proxy individual characteristics, (2) the nature of the target-proxy relationship (e.g., adult child – parent vs. sibling), (3) living arrangement and whether the proxy and target reside in the same household or even city, and (4) delegation of tasks (e.g., financial, medical) and burden of care. Given these potential sources of biases, it is not surprising that information from varied data sources differ. Important questions to address include how assessments by each source vary across performance domain and which data source is the most sensitive to change. These questions are particularly relevant to research questions and populations very late in life as the use of proxy-reports or observation increases because it may be the only method to garner information.

At a conceptual level, three additional issues affect measurement of cognition in later life. One of these difficulties is the characterization of the *structure of cognitive abilities*. While broad class distinctions may remain meaningful, evidence suggests that constituent cognitive abilities begin to differentiate from infancy into adolescence but subsequently may become less differentiated and more similar in late life (e.g., Baltes, Cornelius, Spiro, Nesselroade, & Willis, 1980; Baltes & Lindenberger, 1997; Cunningham, 1980; deFrias, Lövdén, Lindenberger, & Nilsson, 2007). This possibility is debated (e.g., Anstey, Hofer & Luszcz, 2003; Zelinski & Lewis, 2003) and has not been well addressed in very late life. Thus, the question arises as to the distinctiveness of cognitive abilities among the oldest old.

Addressing this issue, May et al. (2010) investigated whether dedifferentiation theory could explain differences on neuropsychological measures between octogenarians and centenarians from the Georgia Centenarian Study. Using a series of principal components analyses with a battery of cognitive measures (Fuld Object Memory Evaluation, Fuld, 1981; Controlled Oral Word Association Test, Benton & des Hamsher, 1976; Similarities subtest from the WAIS-III, Wechsler, 1997; a hand tapping test, and the Behavioral Dyscontrol Scale, Grigsby & Kaye, 1996), both centenarians and octogenarians demonstrated a similar pattern of component loadings across a single component that accounted for approximately 70% of the total variance. Even when participants were stratified into high and low cognitive functioning groups, a single component that accounted for similar

proportions of variance emerged for both age groups within each level of cognitive functioning. Based on these findings, it appears that dedifferentiation may have already taken place by the 9th decade of life. Furthermore, there does not appear to be additional cognitive dedifferentiation that occurs among the oldest old.

Another fundamental assessment concern centers on *measurement equivalence* and the validity of cognitive measures in accurately assessing the same construct across the entire adult age span and over the course of time. Measurement equivalence refers to the ability of a measure to produce a reliable and valid assessment of a construct over individuals, groups, and time (e.g., Labouvie, 1981). Although consistent use of the same assessment tool is often the goal of both cross-sectional (i.e., investigation of inter-individual differences) and longitudinal (i.e., investigation of intra-individual change) studies, this practice can lead to erroneous interpretation due to lack of measurement equivalence. For example, repeated testing of an individual using the same assessment tool may not be appropriate as the measure's ability to assess a construct can change across time. This issue is especially applicable to assessment of cognitive ability across the course of development (e.g., "academic" tests of cognition in childhood may be more appropriate compared to contextual tests of cognition in later life). Older cohorts are likely to be less experienced with standardized testing procedures and stimuli. Items using unfamiliar and/or difficult directions or stimuli may need to be presented in an alternative fashion. For instance, in one study, we quickly realized that a common assessment of inductive reasoning used with young-old and old adults was not understood by centenarian participants (Martin, Deshpande-Kamat, Margrett, Franke, & Garasky, 2012). Thus, instead of a letter series pattern, we introduced patterns of a more easily understood stimulus, fruit, in an attempt to simplify the task (see Figure 1).

Also relevant to this discussion of later life cognitive assessment is consideration of both *performance potential and meaningfulness of the measures*. In regard to the former, researchers posit that testing individuals' cognitive capacity (e.g., "developmental reserve capacity"; what can an older adult do versus what they currently do; Kliegl & Baltes, 1987) may be a more accurate means by which to assess developmental potential. Ecological validity is a related issue impacting investigation of adult development and aging and cognition. There is a rich history in the cognitive aging field concentrated on investigation of what is important to an older adult's daily life and context (e.g., practical intelligence and everyday cognition; e.g., Denney & Palmer, 1981; Marsiske & Margrett, 2006; Poon, Rubin, & Wilson, 1992; Thornton & Dumke, 2005; Willis & Schaie, 1986). This approach has bearing on the types of "practical" performance-based tasks assessed (e.g., well-defined tasks such as completing a tax form as compared to an ill-defined interpersonal problem) as well as how "success" is gauged (e.g., identification of

The next questions are like word games or puzzles. I will ask you to follow a series of letters and choose the letter which comes next. Find the letter in the answer row that follows the last letter of item.	The next questions are like picture puzzles. I will ask you to follow a series of picture and choose the object which comes next.
Look at these pictures.	Look at these pictures.
a b c a b c _____	
Which object comes next?	Which object comes next?
c a d b e	

(a) Standard letter stimuli

(b) Adapted stimuli

**Figure 1.** Example of a test adaptation used to gauge inductive reasoning ability among very old individuals

a single, correct response; generation of several feasible possible responses). Such approaches are rare, but may be particularly relevant to study of cognitive aging among the oldest old in examining age group differences and ensuring veridicality of cognitive assessments over the adult lifespan (Holtsberg, Poon, Noble, & Mapstone-Johnson, 2002).

### Lifespan psychosocial resources and cognition: Opportunities via later life investigations

Study of individuals reaching late life provides extraordinary opportunity to investigate individual differences among extreme survivors. Identification of diverse later life cognitive health profiles and investigation of the factors associated with each profile can lead to increased understanding and ultimately prevention and intervention efforts aimed at enhancing later life cognitive skills. Several manifestations exist which reflect either concordance or discordance between underlying neuropathology and observed behavioral symptoms and performance (see Table 2). Long lived individuals who demonstrate “resilience” or resistance in the face of underlying neuropathology can provide unique and valuable information related to factors protective against cognitive decline (Negash et al., 2014; Perls, 2004b). Persons identified as “resilient” or resistant to dementia (Group C) can provide many avenues for future research. Protective factors underlying resilience may be of a genetic or environmental nature or reflect an interaction between the two. In contrast, persons in the at-risk group (Group B) demonstrate impairment despite the absence of significant neuropathology. Risk factors could reflect

**Table 2.** Cognitive health profiles reflecting later life concordance of neuropathological and behavioral characteristics

Neurological profile	Behavioral symptoms & performance	
	Normal	Impaired
No underlying pathology	Unimpaired – concordant (A)	At-risk (B)
Underlying pathology	Resilient (C)	Impaired – concordant (D)

another underlying genetic disadvantage or an environment which was not conducive to development of personal reserve.

An illustrative example comes from work on personality. The configuration of specific personality traits may determine whether an individual develops personal reserves. Da Rosa (2012), for example, performed latent profile analysis with data from the Georgia Centenarian Study and the Tokyo Centenarian Studies. The results distinguished two different resilience groups among centenarians in both countries. The resilient group had higher scores on Agreeableness and Extraversion and the non-resilient group was characterized by higher scores on Neuroticism and lower scores on Extraversion, Openness, Agreeableness, and Conscientiousness. In the U.S. sample, education and cognitive health explained differences between the two groups.

To further investigate later life cognitive development and health, it is advantageous to incorporate a lifespan approach and realize the impact of multi-level influences.

### Dynamic processes across the lifespan

An integral element to incorporate in investigation of the oldest old is development over time. As noted by Miller et al. (2010), consideration of developmental change is necessary into very late life as even a short interval can reflect significant change. Considering both the theoretical and temporal relations between constructs permits a life-span approach to investigation of later life functioning. To this end, Martin and Martin (2002) provide a framework for investigation of developmental outcomes. Their model provides a useful approach for considering the nature and degree of impact of *distal* (e.g., early childhood environment) and *proximal* (e.g., current individual and social resources, recent experiences) influences. Similarly, Schaie (2005) outlined the model guiding investigation of the Seattle Longitudinal Study. This model also incorporates distal influences from both *childhood* (i.e., family of origin environment and heritable abilities) and

*midlife* (i.e., family environment, socioeconomic status), as well as more proximal influences of illness, and lifestyle behaviors.

As implied by these models, diverse factors shape functioning and quality of life throughout our lives. Illustrating this point, Hensley and colleagues (2010, 2012) demonstrated the impact of lifetime events and early experiences (e.g., childhood health) occurring decades prior, on oldest old persons and centenarians' current personality and mental health. Da Rosa, Martin, Gondo, Hirose, Ishioka, and Poon (2014) also noted that recalling specific life events, particularly marital events, related to personality. Centenarians who were emotionally stable and introverted were more likely to reflect on marriage as the most important event in their life. Furthermore, Martin, da Rosa, and Poon (2011) demonstrated that proximal and distal events experienced by centenarians may be associated with different mental health outcomes. Whereas proximal events (those experienced during the past 20 years) were associated with lower levels of positive affect and higher levels of negative affect, distal events (those experienced more than 20 years ago) were only associated with higher levels of positive affect. Thus, it is clear that earlier life events and development as well as personality shape functional outcomes for the oldest old.

### **Multi-level influences and resources**

Context shaped and continues to shape oldest old individuals and there is a growing emphasis on moving beyond a biomedical model to understand health and quality of life in advanced age (see Poon et al., 2010). To this end, Poon and colleagues cite the relevance of psychosocial variables in maintaining health and quality of life including "(1) demographics, life events, and personal history, (2) personality, (3) cognition, and (4) socioeconomic resources and support systems." Additionally, as noted by Masten (2001), resilience research includes processes at multiple levels from genes to relationships. Both of these approaches are consistent not only a life-span approach, but also with a bioecological perspective which takes into account direct and indirect influences impacting health and quality of life.

Specific to cognition, we would like to highlight concepts proposed by Willis (1991) which set the stage for investigating competency by incorporating direct and indirect influences in a process model. Willis' model outlines antecedents, components, and mechanisms of competency, which in turn predict psychological and physical outcomes. Willis describes individual (micro-level) and sociocultural (societal or macro-level) factors as antecedents to competency. She

conceptualizes components of competency at both the intra-individual and contextual levels; both which are specific to domain or task. The third component to Willis' model is that of mechanisms (e.g., control beliefs), or mediating effects, which help transform components of competency into behavior. Conceptualization of competency antecedents, components, and mechanisms in such a way is particularly amenable to the context of later life as micro- and macro-level factors are considered; in this way contextual similarities and differences among oldest old individuals can be explored and prevention and intervention can be targeted.

In a related line of inquiry intended to promote investigation of genetic and environmental influences on longevity and optimal aging, Gondo et al. (2006) explored the functional profiles of Japanese centenarians. Based on indicators of cognitive and physical functioning, centenarians were designated as being "Exceptional", "Normal", "Frail", or "Fragile." Using their criteria, 80% of centenarians in the sample was categorized as either being "frail" (i.e., either cognitive or physical impairment) or "fragile" (i.e., both cognitive and physical impairment evident). Very few centenarians were deemed to exhibit exceptional functioning in both domains and 18% were identified as preserving "normal" physical and cognitive functioning. Gondo and colleagues noted the importance of considering adaptive responses among the oldest old, as one third of those centenarians classified as "fragile" maintained good cognitive functioning despite physical limitations.

A series of findings from the Georgia Centenarian Study examining the cognitive performance of persons nearing the century mark or beyond, demonstrate the importance of additional factors beyond age, including the foundational demographic characteristics of gender, ethnicity, and education, as well as an indicator of current context, residential status (e.g., community home, skilled nursing facility; Davey et al., 2010; Davey et al., 2013; Miller et al., 2010; and Mitchell et al., 2011). In other work utilizing cognition as a predictor, Margrett et al. (2010, 2011) identified links between individual resources such as executive functioning and personality with the mental health outcomes of depression, loneliness, and affect. A recent study by Martin et al. (2013) demonstrated the interaction of genes and environment as related to centenarians' *APOE ε4* status, life events, and affect, setting the stage for additional investigation of the lifelong interplay of disposition, experience, and interpretation of those experiences.

## Conclusions

In this chapter, we focused on three issues relevant to cognitive-linguistic development in very late life: heterogeneity in older adulthood and diversity of outcomes among the oldest old, challenges to the study of the oldest old, and the role of resources in later life development. Several main points emerged. The first point is that “older adults” as a group are very heterogeneous – this is especially true for the oldest old. Individuals surviving to late life bring with them a vast array of individual experiences and abilities which shape development and adaptation. This effect is amplified with age. Secondly, normative and non-normative cognitive and linguistic aging occur and a diversity of outcomes result. More investigation is needed to better understand the complexities of very late life development including transitions from normative to non-normative changes. We do know that cognitive and linguistic functioning are components of a broader constellation of synergistic abilities underpinning whole-person wellness and together they exert significant impact on the day-to-day functioning of the oldest old. The study of oldest old individuals is challenging for multiple reasons (e.g., sensory and functional impediments to testing, barriers to ecological validity and measurement equivalence). However, investigation of very late life offers an unparalleled window into a period of life full wrought with diversity and rapid change yet filled with survivors and evidence of their adaptation. Related to this point, we highlighted the need to incorporate consideration of psychosocial resources and context. We do not develop, function, or age alone and cognitive and linguistic processes are necessary to traverse everyday life. Understanding and building upon lifespan psychosocial resources, can facilitate oldest old persons in reaping the benefit of their social environments and optimizing their aging experience.

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## References

- Ahn, I. S., Kim, J.-H., Kim, S., Chung, J. W., Kim, H., Kang, H. S., & Kim, D. K. (2009). Impairment of instrumental activities of daily living in patients with mild cognitive impairment. *Psychiatry Investigation*, 6(3), 180–184. doi:10.4306/pi.2009.6.3.180

- Arnold, J., Dai, J., Nahapetyan, L., Arte, A., Johnson, M. A., Hausman, D., Rodgers, W. L., Hensley, R., Martin, P., MacDonald, M., Jazwinski, S. M., & Poon, L. W. (2010). Predicting successful aging in a population-based sample of Georgia centenarians. *Current Gerontology and Geriatrics Research*, 2010, 1–9. doi:10.1155/2010/989315
- American Academy of Neurology (n.d.). *Detection, diagnosis, and management of dementia*. Retrieved from: <[http://tools.aan.com/professionals/practice/pdfs/dementia\\_guideline.pdf](http://tools.aan.com/professionals/practice/pdfs/dementia_guideline.pdf)>
- Andersen-Ranberg, K., Vasegaard, L., & Jeune, B. (2001). Dementia is not inevitable: A population-based study of Danish centenarians. *Journal of Gerontology: Series B: Psychological Sciences and Social Sciences*, 56B, P152–P159. doi:10.1093/geronb/56.3.P152
- Bak, T. H., & Moishi, E. (2007). A cognitive bedside assessment beyond the MMSE: The Addenbrooke's Cognitive Examination. *Practical Neurology*, 7, 245–249.
- Baltes, P. B., Ebner, N. C., & Freund, A. M. (2006). Personal goal orientation from young to late adulthood: From striving for gains to maintenance and prevention of losses. *Psychology and Aging*, 21(4), 664–678. doi:10.1037/to6070-000
- Baldwin, C. L., & Ash, I. K. (2011). Impact of sensory acuity on auditory working memory span in young and old adults. *Psychology and Aging*, 26(1), 85–91. doi:10.1037/a0020360
- Bengtson, V. L. (2001). Beyond the nuclear family: The increasing importance of multigenerational bonds. *Journal of Marriage and Family*, 63(1), 1–16. doi:10.1111/j.1741-3737.2001.00001.x
- Benton, A. L., & des Hamsher, K. (1976). *Multilingual Aphasia Examination*. Iowa City, IA: University of Iowa.
- Bonnie, R. J., & Wallace, R. B. (2002). *Elder mistreatment: Abuse, neglect, and exploitation in an aging America*. Washington, DC: National Research Council.
- Burke, D. M., & Shafto, M. A. (2008). Language and aging. In F. I. M. Craik & T. A. Salthouse (Eds.), *The handbook of aging and cognition* (pp. 373–443). New York, NY: Psychology Press.
- Canevelli, M., Cesari, M., & van Kan, G. A. (2015). Frailty and cognitive decline: How do they relate? *Current Opinion in Clinical Nutrition & Metabolic Care*, 18(1), 43–50. doi:10.1097/MCO.000000000000133
- Cho, J., Martin, P., & Poon, L. W. (2012). The older they are, the less successful they become? Findings from the Georgia Centenarian Study. *Journal of Aging Research*, 2012, 1–8. doi:10.1155/2012/695854
- Colby, S. L. & Ortman, J. M. (2014). The baby boom cohort in the United States: 2012 to 2060. *Current Population Reports*, P25–1141. U.S. Census Bureau: Washington, DC. Retrieved from <<http://www.census.gov/prod/2014pubs/p25-1141.pdf>>
- Cohen-Mansfield, J., Parpura-Gill, A., & Golander, H. (2006). Utilization of self-identity roles for designing interventions for persons with dementia. *Journal of Gerontology: Psychological Sciences*, 61B(4), P202–P212. doi:10.1093/geronb/61.4.P202
- da Rosa, G. D. (2012). *The relationship between personality, life events and healthy longevity: A comparison of U.S. and Japanese centenarians*. Ames, IA: Iowa State University, Graduate Theses and Dissertations. Paper 12865. <<http://lib.dr.iastate.edu/etd/12865>>
- da Rosa, G., Martin, P., Gondo, Y., Hirose, N., Ishioka, Y., & Poon, L. W. (2014). Examination of important life experiences of the oldest-old: Cross-cultural comparisons of U. S. and Japanese centenarians. *Journal of Cross-Cultural Gerontology*, 29, 109–130. doi:10.1007/s10823-014-9223-z

- Dai, T., Davey, A., Woodard, J. L., Miller, S., Gondo, Y., Kim, S.-H., & Poon, L. W. (2013). Sources of variation on the Mini-Mental State Examination in a population-based sample of centenarians. *Journal of the American Geriatric Society*, 61(8), 1369–1376. doi:10.1111/jgs.12370
- Davey, A., Dai, T., Woodard, J. L., Miller, L. S., Gondo, Y., Johnson, M. A., Hausman, D. B., Martin, P., Green, R. C., Allen, R. H., Stabler, S. P., & Poon, L. W. (2013). Profiles of cognitive functioning in a population-based sample of centenarians using factor mixture analysis. *Experimental Aging Research*, 39(2), 125–144. doi:10.1080/0361073X.2013.761869
- Davey, A., Elias, M., Siegler, I. C., Lele, U., Martin, P., Johnson, M. A., Hausman, D. B., & Poon, L. (2010). Cognitive function, physical performance, health, and disease: Norms from the Georgia Centenarian Study. *Experimental Aging Research*, 36, 394–425. doi:10.1080/0361073X.2010.509010
- Denney, N. W., & Palmer, A. M. (1981). Adult age differences on traditional and practical problem-solving measures. *Journal of Gerontology*, 36(3), 323–328. doi:10.1093/geronj/36.3.323
- Diener, E., & Chan, M. Y. (2011). Happy people live longer: Subjective well-being contributes to health and longevity. *Applied Psychology: Health and Well-being*, 3(1), 1–43. doi:10.1111/j.1758-0854.2010.01045.x
- Dillon, C. F., Gu, Q., Hoffman, H. J., & Ko, C. (2010). Vision, hearing, balance, and sensory impairment in Americans aged 70 years and over: United States, 1999–2006. *National Center for Health Statistics Data Brief*, 31, 1–8. PMID: 20377973
- Driscoll, I., & Troncoso, J. (2011). Asymptomatic Alzheimer's disease: A prodrome or a state of resilience? *Current Alzheimer Research*, 8(4), 330–335. doi:10.2174/156720511795745348
- Ewers, M., Sperling, R., Klunk, W. E., Weiner, M. W., & Hampel, H. (2011). Neuroimaging markers for the prediction and early diagnosis of Alzheimer's disease dementia. *Trends in Neurosciences*, 34(8), 430–442. doi:10.1016/j.tins.2011.05.005
- Flynn, J. R. (1987). Massive IQ gains in 14 nations: What IQ tests really measure. *Psychological Bulletin*, 101, 171–191. doi:10.1037/0033-2909.101.2.171
- Flynn, J. R. (2007). *What is intelligence? Beyond the Flynn effect*. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511605253
- Folstein, M., Folstein, S. E., & McHugh, P. R. (1975). "Mini-Mental State." A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, 12(3), 189–198. doi:10.1016/0022-3956(75)90026-6
- Fuld, P. A. (1977). *Fuld Object-Memory Evaluation instruction manual*. Wood Dale, IL: Stoelting.
- George, L. K. (2010). Still happy after all these years: Research frontiers on subjective well-being in later life. *Journal of Gerontology: Social Sciences*, 65B(3), 331–339. doi:10.1093/geronb/gbq006
- Glisky, E. L. (2007). Changes in cognitive function in human aging. In D. R. Riddle (Ed.), *Brain aging: Models, methods, and mechanisms*. Boca Raton, FL: CRC Press. Available from: <<http://www.ncbi.nlm.nih.gov/books/NBK3885/>>
- Gondo, Y., Hirose, N., Arai, Y., Inagaki, H., Masui, Y., Yamamura, K., ....Kitagawa, K. (2006). Functional status of centenarians in Tokyo, Japan: Developing better phenotypes of exceptional longevity. *Journal of Gerontology: Medical Sciences*, 61A(3), 305–310. doi:10.1093/gerona/61.3.305
- Grigsby, J., & Kaye, K. (1996). *Behavioral dyscontrol scale: Manual* (2nd ed.). Authors.

- Hagberg, B., Alfredson, B. B., Poon, L. W., & Homma, A. (2001). Cognitive functioning in centenarians: A coordinated analysis of results from three countries. *Journal of Gerontology: Psychological Sciences*, 56B(3), P141–P151. doi:10.1093/geronb/56.3.P141
- He, W., & Muenchrath, M. N. (2011). *90+ in the United States: 2006–2008 American Community Survey Reports*. Retrieved from <<http://www.census.gov/prod/2011pubs/acs-17.pdf>>
- Hensley, R., Martin, P., MacDonald, M., & Poon, L. (2010). Family history and adaptation among centenarians and octogenarians. *Gerontology*, 56, 83–87. doi:10.1159/000271955
- Hensley, B., Martin, P., Margrett, J., MacDonald, M., Siegler, I. C., & Poon, L. W. (2012). Life events and personality influencing loneliness among centenarians: Findings from Georgia Centenarian Study. *The Journal of Psychology*, 146, 173–188. doi:10.1080/00223980.2011.613874
- Holtsberg, P. A., Poon, L. W., Noble, C. A., & Mapstone-Johnson, M. (2002). Everyday problem-solving in community dwelling cognitively intact centenarians. *Hallym International Journal of Aging*, 4(2), 83–97. doi:10.2190/Q76D-YFKD-YGJ9-XDEB
- Iacono, D., Markesbery, W. R., Gross, M., Pletnikova, O., Rudow, G., Zandi, P., & Troncoso, J. C. (2009). The Nun study: Clinically silent AD, neuronal hypertrophy, and linguistic skills in early life. *Neurology*, 73, 665–673. doi:10.1212/WNL.ob013e3181b01077
- Kelaiditi, E., Cesari, M., Canevelli, M., Abellan van Kan, G., Ousset, P.-J., Gillette-Guyonnet, S...Vellas, B. (2013). Cognitive frailty: Rational and definition from an (I.A.N.A./I.A.G.G.) International Consensus Group. *The Journal of Nutrition, Health and Aging*, 17(9), 726–734. doi:10.1007/s12603-013-0367-2
- Kemper, S., Thompson, M., & Marquis, J. (2001). Longitudinal change in language production: Effects of aging and dementia on grammatical complexity and propositional content. *Psychology and Aging*, 16(4), 600–614. doi:10.1037/0882-7974.16.4.600
- Kertesz, A., Jesso, S., Harciarek, M., Blair, M., & McMonagle, P. (2010). What is semantic dementia? A cohort study of diagnostic features and clinical boundaries. *Archives of Neurology*, 67(4), 483–489. doi:10.1001/archneuro.2010.55
- Kim, H., Chang, M., Rose, K., & Kim, S. (2012). Predictors of caregiver burden in caregivers of individuals with dementia. *Journal of Advanced Nursing*, 68(4), 846–855. doi:10.1111/j.1365-2648.2011.05787.x
- Kliegl, R., & Baltes, P. B. (1987). Theory-guided analysis of mechanisms of development and aging through testing-the-limits and research on expertise. In C. Schooler (Ed.), *Cognitive functioning and social structure over the life course*, 95–114. Norwood, NJ: Ablex.
- Kliegel, M., Moor, C., & Rott, C. (2004). Cognitive status and development in the oldest old: A longitudinal analysis from the Heidelberg Centenarian Study. *Archives of Gerontology and Geriatrics*, 39, 143–156. doi:10.1016/j.archger.2004.02.004
- Labouvie, E. W. (1980). Identity versus equivalence of psychological measures and constructs. In L. W. Poon (Ed.), *Aging in the 1980s* (pp. 493–502). Washington, DC: American Psychological Association. doi:10.1037/10050-036
- Laumann, E. O., Leitsch, S. A., & Waite, L. J. (2008). Elder mistreatment in the United States: Prevalence estimates from a nationally representative study. *Journal of Gerontology: Social Sciences*, 63(4), S248–S254. doi:10.1093/geronb/63.4.S248
- Lesser, R., & Milroy, L. (1993). *Linguistics and aphasia: Psycholinguistic and pragmatic aspects of intervention*. New York, NY: Routledge.
- Lin, F. R., Yaffe, K., Xia, J., Xue, Q.-L., Harris, T. B., Purchase-Helzner, E., Satterfield, S., Ayonayon, H. N., Ferrucci, L., & Simonsick, E. M. (2013). Hearing loss and cognitive decline in older adults. *Journal of the American Medical Association: Internal Medicine*, 173(4). Retrieved from: <<http://archinte.jamanetwork.com/article.aspx?articleID=1558452>>

- MacDonald, M., Martin, P., Margrett, J., & Poon, L. W. (2009). Correspondence of perceptions about centenarians' mental health. *Journal of Aging and Mental Health*, 13(6), 827–837. doi:10.1080/13607860902918249
- Margrett, J. A., Daugherty, K., Martin, P., & MacDonald, M., Davey, A., Woodard, J. L., Miller, L. S., Siegler, I. C., & Poon, L. W. (2011). Affect and loneliness among centenarians and the oldest old: The role of individual and social resources. *Aging and Mental Health*, 15, 385–396. doi:10.1080/13607863.2010.519327
- Margrett, J., Martin, P., Woodard, J., Miller, L. S., MacDonald, M., Baenziger, J., Siegler, I., & Poon, L. W. (2010). Depression among centenarians and the oldest old: Contributions of cognition and personality. *Gerontology*, 56(1), 93–99. doi:10.1159/000272018
- Margrett, J. A., Hsieh, W.-H., Heinz, M., & Martin, P. (2012). Cognitive status and change among Iowa Centenarians. *International Journal of Aging and Human Development*, 75(4), 317–335. doi:10.2190/AG.75.4.b
- Margrett, J. A., Mast, B., Isales, M. C., Poon, L. W., & Cohen-Mansfield, J. (2011). Cognitive functioning and vitality among the oldest old: Implications for well-being. In L. W. Poon & J. Cohen-Mansfield (Eds.), *Understanding well-being in the oldest-old* (pp. 186–212). Cambridge: Cambridge University Press. doi:10.1017/CBO9780511920974.012
- Marsiske, M., & Margrett, J. A. (2006). Everyday problem solving and decision making. In J. E. Birren & K. W. Schaie (Eds.), *Handbook of the psychology of aging* (6th ed.; pp. 315–342). Burlington, MA: Elsevier. doi:10.1016/B978-012101264-9/50017-3
- Martin, P., da Rosa, G., & Poon, L. W. (2011). The impact of life events on the oldest old. In L. W. Poon & J. Cohen-Mansfield (Eds.), *Understanding the well-being of the oldest old* (pp. 96–110). Cambridge: Cambridge University Press. doi:10.1017/CBO9780511920974.008
- Martin, P., da Rosa, G., Siegler, I., Davey, A., MacDonald, M., & Poon, L. W. (2006). Personality and longevity: Findings from the Georgia Centenarian Study. *Age*, 28, 343–352. doi:10.1007/s11357-006-9022-8
- Martin, P., Deshpande-Kamat, N., Margrett, J. A., Franke, W., & Garasky, S. (2012). Introduction to the Exceptional Longevity Study of Centenarians in Rural Environments. *International Journal of Aging and Human Development*, 75(4), 297–316. doi:10.2190/AG.75.4.a
- Martin, P., Jazwinski, M., Davey, A., Green, R., MacDonald, M., Margrett, J. A., Siegler, I., Arnold, J., Woodard, J., Johnson, M. A., Kim, S., Dai, J., Li, L., Batzer, M. A., & Poon, L. W. (2013). *APOE ε4*, life experiences, and affect among centenarians. *Aging and Mental Health*, 18, 240–247. doi:10.1080/13607863.2013.827624
- Martin, P., Kelly, N., Kahana, B., Kahana, E., Willcox, B., Willcox, D. C., & Poon, L. W. (2015). Definitions of successful aging: A tangible or elusive concept? *The Gerontologist*, 55, 14–25. doi:10.1093/geront/gnuo44
- Martin, P., & Martin, M. (2002). Proximal and distal influences on development: The model of developmental adaptation. *Developmental Review*, 22, 78–96. doi:10.1006/drev.2001.0538
- Martin, P., Margrett, J., & Lockhart, P. (in press). Iowa Centenarian Study. In N. Pachana (Ed.), *Encyclopedia of geropsychology*. New Delhi: Springer.
- Martin, P., Poon, L. W., Kim, E., & Johnson, M. A. (1996). Social and psychological resources of the oldest old. *Experimental Aging Research*, 22, 121–139. doi:10.1080/03610739608254002
- Masten, A. S. (2001). Ordinary magic. *American Psychologist*, 56, 227–238. doi:10.1037//0003-066X.56.3.227
- May, P. E., Woodard, J. L., Miller, L. S., Martin, P., Davey, A., & Poon, L. W. (2010, November). An investigation of the dedifferentiation theory among the oldest old. *The Gerontologist*, 50, 283.

- Michel, J.-B., Shen, Y. K., Aiden, A. P., Veres, A., Gray, M. K., The Google Books Team, Pickett, J. P., Hoiberg, D., Clancy, D., Norvig, P., & Orwant, J. (2010). Quantitative analysis of culture using millions of digitized books. *Science*, 331(6014), 176–182. doi:10.1126/science.1199644
- Miller, L. S., Mitchell, M. B., Woodard, J. L., Davey, A., Martin, P., & Poon, L. W. (2010). Cognitive performance in centenarians and the oldest old: Norms from the Georgia Centenarian Study. *Aging, Neuropsychology, & Cognition*, 17(5), 575–590. doi:10.1080/13825585.2010.481355
- Mitchell, M. B., Miller, L. S., Woodard, J. L., Davey, A., Martin, P., Burgess, M., & Poon, L. W. (2011). Regression-based estimates of observed functional status in centenarians. *The Gerontologist*, 51(2), 179–189. doi:10.1093/geront/gnq087
- Mitchell, M. B., Miller, L. S., Woodard, J. L., Davey, A., Martin, P., & Poon, L. W., For The Georgia Centenarian Study. (2013). Norms from the Georgia Centenarian Study: Measures of verbal abstract reasoning, fluency, memory, and motor function. *Aging, Neuropsychology, and Cognition*, 20(5), 620–637. doi:10.1080/13825585.2012.761671
- Morris, J. C. (1993). The Clinical Dementia Rating (CDR): Current version and scoring rules. *Neurology*, 43, 2412–2414. doi:10.1212/WNL.43.11.2412-a
- National Institutes on Aging (2011). *Global health and aging*. Retrieved from: <http://www.who.int/ageing/publications/global\_health.pdf>
- Negash, S., Wilson, R. S., Leurgans, S. E., Wolk, D. A., Schneider, J. A., Buchman, A. S., Bennett, D. A., & Arnold, S. E. (2013). Resilient brain aging: Characterization of discordance between Alzheimer's disease pathology and cognition. *Current Alzheimer Research*, 10(8), 844–851. doi:10.2174/15672050113109990157
- Njegovan, V., Man-Son-Hing, M., Mitchell, S. L., & Molnar, F. J. (2001). The hierarchy of functional loss associated with cognitive decline in older persons. *Journal of Gerontology: Medical Sciences*, 56A(No. 10), M638–M643. doi:10.1093/gerona/56.10.M638
- Organisation for Economic Co-operation and Development (2011). "Life expectancy at birth", in *Health at a Glance 2011: OECD Indicators*, OECD Publishing. Retrieved from doi:10.1787/health\_glance-2011-4-en
- Perls, T. (2004a). Centenarians who avoid dementia. *Trends in Neurosciences*, 27(10), 633–636. doi:10.1016/j.tins.2004.07.012
- Perls, T. (2004b). Dementia-free centenarians. *Experimental Gerontology*, 39, 1587–1593. doi:10.1016/j.exger.2004.08.015
- Pernecky, R., Pohl, C., Sorg, C., Hartmann, J., Tomic, N., Grimmer, T., Heitele, S., & Kurz, A. (2006). Impairment of activities of daily living requiring memory or complex reasoning as part of the MCI syndrome. *International Journal of Geriatric Psychiatry*, 21, 158–162. doi:10.1002/gps.1444
- Poon, L. W., Crook, T., Davis, K. L., Eisdorfer, C., Gurland, B. J., Kaszniak, A. W., & Thompson, L. W. (1986). *Handbook for clinical memory assessment of older adults*. Washington DC: American Psychological Association. doi:10.1037/10057-000
- Poon, L. W., Martin, P., Bishop, A., Cho, J., daRosa, G., Deshpande, N., Hensley, R., MacDonald, M., Margrett, J., Randall, K., Woodard, J., & Miller, L. S. (2010). Understanding centenarians' psychosocial dynamics and their contributions to health and quality of life. *Current Gerontology and Geriatrics Research*, Special Issue (D. C. Willcox, B. Willcox, & C. Franceschi, Guest Editors). doi:10.1155/2010/680657
- Poon, L. W., & Perls, T. T. (2007). The trials and tribulations of studying the oldest old. *Annual Review of Gerontology and Geriatrics*, 27, 1–10.

- Poon, L. W., Rubin, D. C., & Wilson, B. A. (Eds.). (1992). *Everyday cognition in adulthood and late life*. Cambridge: Cambridge University Press.
- Poon, L. W., Woodard, J. L., Miller, L. S., Green, R., Gearing, M., Davey, A., Arnold, J., Martin, P., Siegler, I. C., Nahapetyan, L., Kim, Y. S., & Markesbery, W. (2012). Understanding dementia prevalence among centenarians. *Journal of Gerontology A Biological Sciences & Medical Sciences*, 67A(4), 358–336. doi:10.1093/gerona/glr250
- Rabbitt, P., Lunn, M., Pendleton, N., & Yardefagar, G. (2011). Terminal pathologies affect rates of decline to different extents and age accelerates the effects of terminal pathology on cognitive decline. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*, 66(3), 325–334. doi:10.1093/geronb/gbro26
- Rahman-Filipiak, A., Woodard, J. L., Miller, L. S., Martin, P., Davey, A., & Poon, L. W. (2014). Octogenarian and centenarian performance on the Fuld Object Memory Evaluation. *Ageing, Neuropsychology, and Cognition*, (ahead-of-print), 1–14.
- Randall, G. K., Martin, P., Johnson, M. A., & Poon, L. W. (2012). Successful aging: A psychosocial resources model for very old adults. *Journal of Aging Research*. Article ID 934649, 11 pages. doi:10.1155/2012/934649
- Rowe, J. W., & Kahn, R. L. (1997). Successful aging. *The Gerontologist*, 37(4), 433–440. doi:10.1093/geront/37.4.433
- Sadana, R., Foebel, A. D., Williams, A. N., & Beard, J. R. (2013). Population aging, longevity, and the diverse contexts of the oldest old. *Public Policy and Aging Report*, 23(2), 18–25. doi:10.1093/ppar/23.2.18
- Satariano, W. A., Scharlach, A. E., & Lindeman, D. (2014). Aging, place, and technology toward improving access and wellness in older populations. *Journal of Aging and Health*, 26(8), 1373–1389. doi:10.1177/0898264314543470
- Saxton, J., McGonigle-Gibson, K. L., Swihart, A. A., Miller, V. J., & Boller, F. (1990). Assessment of the severely impaired patient: Description and validation of a new neuropsychological test battery. *Psychological Assessment: A Journal of Consulting and Clinical Psychology*, 2, 298–303. doi:10.1037/1040-3590.2.3.298
- Schaie, K. W. (1996). *Adult intellectual development: The Seattle Longitudinal Study*. New York: Cambridge University Press.
- Schaie, K. W. (2005). *Developmental influences on adult intelligence: The Seattle Longitudinal Study*. Oxford: Oxford University Press. doi:10.1093/acprof:oso/9780195156737.001.0001
- Schaie, K. W. (2012). *Developmental influences on adult intelligence: The Seattle Longitudinal Study* (2nd ed.). Oxford: Oxford University Press. doi:10.1093/acprof:osobl/9780195386134.001.0001
- Schaie, K. W., Willis, S. L., & Pennak, S. (2005). An historical framework for cohort differences in intelligence. *Research in Human Development*, 2(1–2), 43–67. doi:10.1080/15427609.2005.9683344
- Schwartz, B. L. & Brown, A. S. (Eds.). (2014). *Tip-of-the-tongue states and related phenomena*. Cambridge: Cambridge University Press. doi:10.1017/cbo9781139547383
- Setti, A., Finnigan, S., Sobolewski, R., McLaren, L., Robertson, I. H., Reilly, R. B., ... & Newell, F. N. (2011). Audiovisual temporal discrimination is less efficient with aging: An event-related potential study. *NeuroReport*, 22, 554–558. doi:10.1097/WNR.0b013e328348c731
- Shrestha, L. B. (2005). Life expectancy in the United States. *Congressional Research Service*, 1–29.

- Sperling, R. A., Aisen, P. S., Beckett, L. A., Bennett, D. A., Craft, S., Fagan, A. M.... Phelps, C. H. (2011). Toward defining the preclinical stages of Alzheimer's disease: Recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. *Alzheimers and Dementia: The Journal of the Alzheimer's Association*, 7(3), 280–292. doi:10.1016/j.jalz.2011.03.003
- Suitor, J. J., Sechrist, J., Gilligan, M., & Pillemer, K. (2011). Intergenerational relations in later-life families. In R. A. Settersten & J. L. Angel (Eds.), *Handbook of sociology of aging* (pp. 161–178). New York, NY: Springer. doi:10.1007/978-1-4419-7374-0\_11
- Suzman, R., & Riley M. W. (1985). Introducing the “oldest old”. *Health and Society*, 63(2), 177–186.
- Thornton, W. J., & Dumke, H. A. (2005). Age differences in everyday problem-solving and decision-making effectiveness: A meta-analytic review. *Psychology and Aging*, 20(1), 85–99. doi:10.1037/0882-7974.20.1.85
- Von Humboldt, S., & Leal, I. (2015). The diverse perspectives on adjustment to aging among the old and the oldest old. *European Psychiatry*, 30, 1427. doi:10.1016/S0924-9338(15)31103-2
- Wechsler, D. (1981). *Manual for the Wechsler Adult Intelligence Scale*, Revised. New York, NY: Psychological Corporation.
- Wechsler, D. (1997). *Wechsler Adult Intelligence Scale – Third Edition (WAIS–III)*. San Antonio, TX: Harcourt Assessment.
- Willis, S. L. (1991). Cognition and everyday competence. In K. W. Schaie (Ed.), *Annual Review of Gerontology and Geriatrics*, Vol. 11 (pp. 80–109). New York, NY: Springer.
- Willis, S. L. (1996). Everyday cognitive competence in elderly persons: Conceptual issues and empirical findings. *The Gerontologist*, 36(5), 595–601. doi:10.1093/geront/36.5.595
- Willis, S. L., & Schaie, K. W. (1986). Practical intelligence in later adulthood. In R. J. Sternberg & R. K. Wagner (Eds.), *Practical intelligence: Nature and origins of competence in the everyday world* (pp. 236–268). Cambridge: Cambridge University Press.
- Zimmerman, S., Anderson, W., Brode, S., et al. (2002). Comparison of characteristics of nursing homes and other residential long-term care settings for people with dementia. (Executive Summary). Rockville, MD: Agency for Healthcare Research and Quality: *Comparative Effectiveness Reviews*, 79. Retrieved from: <<http://www.ncbi.nlm.nih.gov/books/NBK114588/>>

## Sociolinguistics, language, and aging

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Using a sociopragmatic lens, we highlight recent strands of research focusing on two of the three main areas identified by Hamilton (1999): the use of language for reflecting and creating identities; and how discourse can reflect the norms, values and practices of society. We focus on studies of the areas of gender and the Internet to show how they emphasize the norms, values and practices of aging. We have assumed that the clinical aspects of Hamilton's third area, the decline, preservation or improvement of abilities in old age, have been incorporated in other sections of this volume, although we note several areas that have stimulated work in sociolinguistics. Growing emphases on identity, particularly as entwined with gender and language abilities, complicate perspectives on aging and language in a discipline with bifurcated if often complementary methodologies of variation and discourse analysis. Illustrations include brief case studies of specific language usage, such as extenders (*and all that stuff*) and media and the Internet, including the use of corpora in the sociolinguistic study of aging.

### Introduction

Age and impairment do not necessarily mean deterioration but they frequently do bring change, in language as in other aspects of life. Until the early nineteen-nineties, details of the changes in language associated with aging have not have been examined from a sociolinguistic point of view. Notable exceptions to this lack were state-of-the-art articles such as Kemper et al. (1989), who reviewed progress over the previous decade in applied and psycholinguistic studies, and studies pulling together work from communications, gerontology and linguistics, such as *Language, society and the elderly: Discourse, identity and ageing* by Coupland and Giles (1991a). The mid nineteen-nineties saw social contexts discussed in studies of changes in the speech or writing of well-known people such as Ronald Reagan and Iris Murdoch who had been diagnosed with Alzheimer's disease and for whom sufficient speech or writing was available for analysis, and initial studies

from a sociolinguistic perspective of persons with acquired communications disorders, such as work on dementia by Hamilton (1994) or Ramanathan (1997). Today it is considered relevant to examine the language of ordinary people and those whose aging is not marked by overt cognitive decline. This change can be seen in the number of recent compilations on language and aging that bridge several disciplines, including collections such as *Dialogue and Dementia: Cognitive and Communicative Resources for Engagement* (Schrauf & Mueller, 2014) and special issues of journals such as that for *Ageing and Society*, in August 2009, edited by Justine Coupland.

One example of a study of “ordinary people” that has moved into general cultural knowledge through public radio and news media is the “Nun study” (Snowdon et al., 1996; Kemper et al., 2001). This was begun by Snowdon in 1986 and is currently housed at the University of Minnesota. It analyzed the early biographical writings by the Sisters and showed a linkage between greater linguistic complexity (such as the ability to produce complex sentences with more embedded clauses) and lower risk of cognitive impairments. The project also collected and analyzed the brains of 600 sisters who have died and continues to test the roughly fifty sisters still living. Kemper et al. (2001) were able to link low linguistic ability (as indicated by low grammatical complexity or low idea density) to low vocabulary and to what could be “suboptimal neurocognitive development” (p. 227). The emphasis in studies of the Sisters’ writing has not to date been from a sociolinguistic perspective, although work on idea density is being examined from the viewpoint of sociolinguistic variation (Chand et al., 2010).

Researchers caution that simpler sentences by younger writers do not necessarily mean a later diagnosis of dementia. However, the emphasis on complexity, or idea density, and on lexical density, or vocabulary, has led researchers to use density to analyze the writings of other older authors, notably Ronald Reagan, Iris Murdoch and Agatha Christie. Venneri et al. cite Butterworth’s 1984 analysis of Reagan’s speeches before re-election, which showed “subtle alterations of language” (2005, p. 128). Garrard et al. (2005) used computer-supported analysis to study lexical density and some features of syntactic complexity in three novels from the beginning, ‘prime,’ and end of Murdoch’s writing career. They found that the final novel, published before her announced diagnosis, showed a more restricted vocabulary, with greater repetition, consistent with expected cognitive deterioration. Vocabulary changes were again the focus in a study of Agatha Christie by Lancashire and Hirst (2009), who looked at excerpts from 14 novels across her writing career. They found the richness of her vocabulary, shown by repeated phrases and definite as opposed to indefinite words such as ‘thing,’ decreased as her age increased. Le et al. (2011) added P. D. James to their study as a contrast. James aged healthily, and analysis of her writing gave support for

the earlier hypotheses about dementia in the writings of Christie and Murdoch. Christie's lexical density had decreased by roughly a fifth, or 20%; Murdoch's vocabulary as well as syntax diminished greatly. In contrast to both Christie and Murdoch, James's later writings did not show decreases in vocabulary variety or specificity. Nor did they show decreased syntactic complexity in terms of mean length of utterance or number of clauses per utterance.

In addition to the growing use of lexical and idea density over the last decade (Brown et al., 2008; Chand et al., 2012; Ferguson et al., 2014), researchers in sociolinguistics analyze language change across time in particular contexts for persons who are not presumed to be cognitively impaired. This move creates a bridge from the more clinical and psycholinguistic studies that have been the major focus of language and aging to sociopragmatic analyses of language change. Abe (2011), for example, reviews changes in American economist Alan Greenspan's language across an economic cycle of expansion and downturn. One of her major findings is that his language use shows "a significant decrease in cognitive complexity during the transition from economic expansion to downturn period" (2011, p. 219). Style shifting via pronunciation is a focus in sociolinguistic research, and is beginning to be applied to analyses of well-known persons for whom data is readily available. For example, Kwan (2014) draws on sociolinguistic variation and acoustic evidence to examine changes in Noam Chomsky's vowels across his lifespan. She shows that, as an adult and after the critical period for language acquisition, Chomsky adopted features of a new dialect (Boston) that differed from his original Philadelphia speech. And a group of Laurel MacKenzie's students at Manchester studied the language of celebrities David and Victoria Beckham (soccer and fashion, respectively). Using YouTube online videos before and after a 2007 move to America, students found they changed their pronunciation by dropping several features associated with working-class speech in the UK <<http://www.manchester.ac.uk/discover/news/article/?id=9856>>. Although it is not possible to state that Chomsky and the Beckhams deliberately changed their language when they moved, the observed changes demonstrate that adults as they age are able to change their language to be closer to the norms of a new community well after the critical period for language acquisition.

In this chapter we will first place studies of language and aging within their sociolinguistic context, and attempt to bridge the gap between sociolinguistics and more clinical approaches to aging. We will then examine identity and gender as two specific aspects of language and aging. A consideration of the way the media treats aging leads us into a discussion of two corpora where the language of older speakers is valued in its own right and used to throw light on earlier stages of current languages.

## Bridging sociolinguistics and clinical findings in spontaneous language maintenance and decline

Our basic knowledge about specific features of older adult speech has expanded and is treated in other chapters in this volume. Some discussions are particularly relevant to sociolinguistic research. For example, Mortensen et al. (2006, p. 239) finds that the greater verbosity in the speech of older adults may be keyed to the use of “‘filler’ words (e.g., well, you know) or repeat words to compensate for difficulties in retrieving names of objects or persons.” These are used to buy processing time for production. Pauses and extenders (*and things like that*) are often used as pragmatic compensation devices by persons with and without cognitive impairment: see Davis (2010) and Maclagan et al. (2008). We include below a short case study of extenders in the speech of older adults. Holtgraves and McNamara (2010) examine the sociopragmatic usage of politeness in speakers with Parkinson’s disease. Chapman and Mudar (2013, p. 520) update information on the cognitive process by which people create discourse gist reasoning which, like current interventions keyed to brain plasticity (Oberman & Pascal-Leone, 2013), can support cognitive rehabilitation. Shafto and Tyler (2014) caution us against interpreting data too simplistically in their report on the specialized brain networks underlying language interaction: they highlight “challenges in determining whether age-related neural changes signify deterioration of specialized subcomponents of the language system, reorganization of language processes, or changing dynamics between language and other cognitive domains” (p. 583).

Researchers in discourse in sociolinguistics and pragmatics, as well as gerontology and communication studies, consider social context important for the analysis of oral and written narratives by older people. Interestingly, much of this focus has come through new directions in caring for elders whose language is impaired. This is one of the emphases discussed in the seminal collection on language and aging, edited by Heidi Hamilton (Hamilton 1999) as well as in her 2001 essay on that topic (Hamilton, 2001). Hamilton’s longitudinal study of conversations with Elsie, a woman with Alzheimer’s disease (Hamilton, 1994), reviews different speech events across different times. Her careful examination of the Oppen family letters (2000) again works across time periods, but with a specific focus on identity in old age. Ramanathan (1995) draws on interactional features of discourse to examine changes in narrative by a single cognitively impaired person speaking in two distinctly different settings, a day care center and at home. In her discussion of sociolinguistics and dementia (2008), Hamilton cites work by several researchers, including Davis and Bernstein (2005) who question the dependence in clinical testing on ‘empty’ words, such as *thing*, concluding that, as Hamilton notes,

coding of “empty” language as part of a semantic richness analysis may well be too simplistic and needs to be carried out with an understanding of the discursive, social, and physical environments. (2008, p. 101)

More recent collections with a sociopragmatic emphasis on discourse include Davis (2005), Guendouzi and Mueller (2005), and Davis and Guendouzi (2014). Key journals in sociolinguistics holding articles on language and aging include *Journal of Sociolinguistics*, *Language Variation and Change*, *Language in Society*. In addition, see *Discourse Studies*, *Journal of Politeness Research*, *Journal of Pragmatics*, *Language and Social Psychology*, *Discourse and Society*, *Discourse and Communication*, *Critical Discourse Studies* and *Research on Language and Social Interaction*.

Each of these threads – an emphasis on social contexts, a focus on identity, and the use of two different sociolinguistic currents to look at language across time and place – can be seen in the burgeoning investigations of language and aging by sociolinguists. We begin by looking briefly at two major sociolinguistic currents, variation and discourse.

### Language variation and discourse approaches in sociolinguistics

The only thing constant about language change is that it is, well, constant, but the changes that are occurring can vary at different times for different speakers or communities of speakers. Variationist studies emphasize quantificational analysis of one or more specific variables (or styles) showing language change either in a community or an individual. This goes beyond pronouncing *tomayto* as *tomahto* to look at whether the change from one to the other is predictable for certain areas or regions or groups of people of various characteristics. As Eckert (1997) explains in her landmark discussion of age as a variable, “adulthood has emerged as a vast wasteland in the study of variation.” Justine Coupland (2009b, p. 850) expands this by saying

Even when sociolinguists focus on ‘change’ (a topic which is still a mainstay of the discipline), it tends to be in a framework that highlights ‘language change’ rather than language as it is implicated in the processes of personal and social ageing... Ageing is still, in a general sense, the unwritten chapter of sociolinguistics.

The **variationist approach** and its associated methodologies have undergone several stages, or waves, in their development and are currently considered to be in their third wave. First-wave variationist sociolinguistics focused on surveys; the second wave emphasized ethnographic approaches and the exploration of

social networks. As Eckert explains on her website, summarizing her longer article (2012):

...Third wave focuses on the social meaning of variables. It views styles, rather than variables, as directly associated with identity categories, and explores the contributions of variables to styles.

<https://web.stanford.edu/~eckert/thirdwave.html>

As an example of first-wave studies, Labov (1972) identified social stratification as a crucial variable in his study of when New Yorkers pronounced (r), in the words *forth floor* using department stores catering to differing socioeconomic groups. Mather's (2012, p. 338) replication "suggests that lower-middle-class younger speakers use the [r]-less variant considerably less than older speakers, contrary to Labov's original survey." The implication here is that the use of (r) has changed generationally in this speech community. Both of these studies rely on what linguists call 'apparent time', in which the researcher relies "on earlier records from the same speech community" (Mather, 2012, p. 340) for a longitudinal trend study in which speakers are not the same. (In a longitudinal panel study, speakers would be the same, and would be recorded at different points in time.) Age-graded changes, on the other hand, are age-cohort related, and can include generational change (Wagner, 2012). Coulmas and Backhaus (2009, p. 5) explain the situation:

The differences in the speech of speakers of different generations observed at the same time can mean one of two things: age grading or ongoing language change. The former means that successive generations repeat similar patterns of preferences for different speech forms and styles as they grow older, while the latter means that older forms are being replaced by new ones by the entire speech community.

Both they and Cheshire (2008) identify a number of issues which can affect sociolinguistic and sociopragmatic investigations of language variation and change in aging, such as culture-specific emphasis (or its lack) on aging, global changes in life expectancy, migrations, culturally-based expectations for education and social mobility by gender, shifts in generational populations, and the like.

**Sociophonetics**, a relatively new field, combines acoustic analyses of the sounds of speech with sociolinguistic work on class, gender, and age stratification such as the investigation of changes in the vowel sounds of English as spoken by Queen Elizabeth II in Christmas speeches between the 1950s and 1980s (Harrington et al., 2000; cf. Labov, 2006). Over this time period, there was considerable change in British English. Changes in the Queen's speech were similar

to these changes, but considerably less marked. Indeed, Harrington et al comment (p. 927) that the Queen's accent has "drift[ed]" toward that of younger, less socially prominent speakers, although it is still recognizable as Standard Southern British. In another study, Walker (2007) showed that subtle phonetic changes in a speaker's production of speech affect how their age and social class are perceived. Recorded sentences were digitally manipulated to change features that vary according to social class in New Zealand English including the degree of aspiration in final (t) in sentences like *It's the only home Jane's got*. Listeners assigned different classes to the speakers in accordance with the predictions. Discussion of sociophonetic analyses keyed to biological age as well as life stage can be found summarized and contextualized in state-of-the-art chapters by Foulkes, Scobbie and Watt (2010) and Thomas (2011).

**Discourse analysis** is also presenting a new wave of analysis from a sociolinguistic/ sociopragmatic perspective, with new and more complex ways of looking at age and aging across the lifespan – where lifespan has become the newly preferred word – and a new focus on intergenerational interaction. Sociolinguistic discourse analysis has expanded from studies of identity and recalibrations of narrative analysis, and now also draws on features from communications studies and applied conversation analysis that intersect with clinical perspectives. The following brief discussion will suggest current trends by highlighting work from a few of these studies. In addition we reference recent and selected studies to exemplify these research threads.

Over the last thirty-five years, Nikolas Coupland has published multiple studies of language, discourse and aging, often enfolded within larger examinations of discourse, identity, and theory. He often writes with scholars in gerontology and communications studies, both of which fields are hospitable to sociolinguistic explorations. For example, his 2004 discussion of "Age in social and sociolinguistic theory" updates his earlier studies and offers a useful overview. In his presentation of new work and new forms in "the social organization of the life course" (p. 77), he notes the paucity of sociolinguistic studies of language in the "social experiencing" (p. 69) of adulthood. Where Nikolas Coupland is frequently concerned with life course (often termed lifespan by other linguists), styles, and communication accommodation theory, Justine Coupland has often been more focused on literal and metaphorical embodiment of aging. Her introduction to a special issue of *Ageing and Society* (Coupland, J., 2009b, p. 251) contextualizes current explorations of identity, beginning with a comment on what sociolinguists need to investigate:

If ageing is treated as something that we achieve in the minutiae of our social lives, in social encounters of diverse sorts and even in individual acts of expression in speech and writing, we may come to understand how social ageing (treated now as a matter of sociocultural norms, expectations, demands, constraints and opportunities) takes the forms it does.

## Language and aging identities

One area where sociolinguists interested in discourse analysis have been active is that of identities. Most researchers working in sociolinguistics and pragmatics would assert that nobody has just one, but instead has a “constellation” of identities (DeFina, 2006, p. 2), and would also insist that identity is co-constructed and negotiated in interaction. As Nikander (2009: 865) comments, discussing discursive and sociolinguistic work on aging, “discursive work provides a means for empirical tests of post-modern notions of age.” Both her study, and the following one by Norrick (2009), appear in a special issue of *Ageing and Society* edited by Justine Coupland. Norrick’s work often combines techniques from conversation analysis with sociopragmatic perspectives. He illustrates this in his discussion (2009, p. 904) of how older narrators construct multiple identities such as “the ‘now’ me and the ‘then’ me”, the “‘teller’ me and the ‘character’ me” when they tell stories, and thereby “force their listeners to recognize two or more of the speaker’s competing identities.”

Since the mid-1990s, Michael Bamberg has been working with the intersections of identity and narrative. As part of a triad of scholars with Alexandra Georgakopoulou and Anna De Fina (see Bamberg, De Fina, & Schiffrin, 2011), these scholars have expanded researchers’ understanding of theories of positioning, canonical and non-canonical narrative, and situated identities, more recently expanding their analyses to incorporate aging. Bamberg’s work, though focused primarily on identity formation in youth, has analyzed constructs which are being extended to look at identity, narrative and aging. For example, De Fina and Georgakopoulou (2008) illustrate the move from the canonical analysis of narrative with a well-defined beginning, series of complications, and a clear ending (plus or minus a teller’s evaluation) to “small stories” (Georgakopoulou, 2006). These are fragmentary stories that have been “marginalized or excluded” from researcher attention (De Fina & Georgakopoulou, 2008, p. 180) but which, as explained in Davis, Maclagan and Cook (2014), are typical of conversational stories co-constructed in dementia conversation.

Narrative *references* are explained by De Fina as being like Georgakopoulou’s *small stories*. They can, as in De Fina (2013, p. 171), be about how older people

are perceived by others. For example, we gain understanding about older men, fathers and grandfathers from the narrative references and heritage narratives offered by adult members of an Italian men's card-playing group. The older adults to whom they refer and whom they describe in their interactions are the glue that legitimate them as card-players and strengthen their affiliation with each other as Italian. In her co-edited collection (De Fina & Georgakopoulou, 2012), De Fina provides a fine overview of trends in the study of theoretical frameworks linking discourse and identity that break from a one-to-one association of a social category with a linguistic phenomenon to focus instead on recent distinctions about the self and the linguistic practices of different communities (pp. 264ff.). Such distinctions can be seen in differentiations such as those cited in Schiffrin's study of narrative in Holocaust oral histories (2002, p. 316) between identities as social categories and the persons/narrators who "take up a certain identity at a specific time and place." (Schiffrin's several discussions of Holocaust narratives (2000, 2001a, b) do not focus exclusively on aging, but instead weave issues of aging and language into studies of the intergenerational interactions about what content people choose to relate about crucial events in their lives over time.)

In order to underscore the need for researchers to examine the flexibility of age-based identities, Georgakopoulou and Charalambidou (2011) explore the linguistic practices people use as they "do aging." They begin with a comment that "heterogeneity in social, physical and mental functioning of over 60s and in social perceptions about them has given rise to the need to define different 'stages' of old age: e.g. 'young-old' or 'third agers' and 'old-old' or '4th agers'" (2011, p. 32). Their study illustrates the incorporation of gerontology as well as communication studies (i.e. Communication Accommodation Theory: see Coupland, Coupland, and Giles, 1991b) to expand previous constructs of age/aging in sociolinguistics.

## Language, aging and gender

Within the general expansion of gender studies, work on gender, language and aging (GLA) from the sociolinguistic perspective is available, if not plentiful. This can in part be attributed to the fact that many of the explorations of GLA have been tied into new currents in the discussion of identity/identities. Another reason is because a good deal of sociolinguistic work, whether from a discourse or a language variation perspective, has focused on adolescents.

Gist and colleagues issued two briefs on gender and aging. Their brief on the world distribution of older women (Gist & Velkoff, 1997) revealed that a majority of older women live in developing countries as opposed to developed ones. That majority, currently at 58% and predicted to become roughly three-quarters

of women over 60 across the world by 2025, is partly due to lower fertility rates, partly to increased longevity, and to a great extent, to population sizes in different parts of the world. Smaller families and involuntary infertility in many regions will present issues for supporting the population as it ages; news reports on aging regularly investigate such issues. How does language fit in?

If Eckert's 1997 discussion of "Age as a sociolinguistic variable" was important for sociolinguistic variation studies, her study with McConnell-Ginet, *Language and Gender* (2003), also infused gender studies with new perspectives. On the second page, they calmly explained that "Gender is not something we are born with, and not something we *have*, but something we *do* ... something we *perform*" [original emphasis] (2003, p. 10). Given current scholarship on identity, discourse and aging, one might want to substitute *age* for *gender* in that sentence.

Cameron (2005, p. 23) addresses interconnections between age and gendering, using varieties of spoken Spanish to address the issue of gender separation (cf. Cameron, 2011). He starts with this statement drawn from his review of previous research: "Because age segregation varies with stage of life, one may predict that gender segregation would wax and wane across the lifespan." His claim, based on a summary of research on sociolinguistic variables, is that nothing bifurcates or dichotomizes easily into anything like a dual culture model where people can be simply categorized into young versus old and male versus female. Instead,

the experience and construction of gendered behaviors varies in content, manner, relevance, and degree of salience across contexts of situated, co-constructed, moment-to-moment talk-in-interaction, and across categories of social membership such as age, class, club, community, country, education, ethnicity, health, language, sexuality, or sport. (2005, p. 28)

And, since from a social constructionist perspective, variables can blur into each other, we add the category of *community of practice*. Communities of practice are described by McConnell-Ginet who says that 'social identities, including gendered identities, arise primarily from articulating memberships in different communities of practice' (2003, p. 71). In a discussion of gender practices for naming, she comments (2003, p. 81) on various kinds of social labeling of older men and women such as the use of *Ms* (or *Mizz* in the southeastern USA), *Miss* or *Mrs* for an older woman and *Mr* plus an initial (*Mr G.*) for an older man. Cameron notes that social constructivist theory critiques sociolinguistic variation for "disregarding the situated, socially constructed, and fluid nature of gender expression, as well as for taking difference between male and female speakers as primary" (p. 52). He addresses these concerns by explaining that sociolinguists examine "different stages of life, loosely indicated by chronological age, as contexts" and

thereby find “systematic zig-zagging in degree of gender differences across the lifespan” (p. 53).

What we do not see are as many studies in sociolinguistics as opposed, for example, to gerontology, that show how language and gender might interact to construct discourse *of* or *in* older people or the aging process involving older people as part of the lifespan. A fine example of both intersections, however, can be seen in a series of studies of conversation among older Japanese women by Matsumoto. In 2009, she shows how their conversational interaction interrogates stereotypes such as painful self disclosure and asexuality. A second study, based on 5 years of data collection, shows how humor allows speakers to reframe their identities (2011a) and a third (2011b, p. 591) emphasizes “an interesting discourse strategy of ‘reframing’ a painful event to ‘quotidian’” which allows the event to become a minor, everyday kind of occurrence through the use of humor and detail. Another example is that of Justine Coupland, who investigates the literal and metaphorical embodiment entwining gender and aging in a number of studies, such as her discussion of gender commodification in cosmetics for men and women who are aging (2009a), and her analysis of dance and aging bodies (2013).

Analysts interested in the confluence of aging, language and gender often combine disciplines such as sociology and linguistics or linguistics and communications studies. See, for example, the *Handbook of Communication and Aging Research* (Nussbaum & J Coupland, 2004), and more than twenty years of collaboration involving prominent scholars such as Howard Giles with sociolinguists, published in journals such as *Ageing and Society* and *Journal of Language and Social Psychology*. Seale and Charteris-Black (2008), a sociologist and a linguist who also specializes in metaphor, combine forces to look at how age and gender interact in illness narratives, “through a controlled comparison of older, middle-aged and younger men’s and women’s linguistic performances of gender” (p. 1026). Their article is one of several they have co-authored on different aspects of the topic; it can serve as an example of “what Coupland called the setting of geriatric medicine” (Coupland N., 1997, p. 39; Seale & Charteris-Black, 2008, p. 1029). Interviews are drawn from the international DIPEX project <<http://www.dipex-international.org/>>, which collects spoken interviews from persons with a range of health conditions for qualitative analysis, by approved research teams; sites in each country present transcripts pertinent to various conditions. They follow up with a discussion specifically targeting men (Charteris-Black & Seale, 2009). They identify a range of male responses to illness: “The experience of undergoing often life-threatening illness leads some men to explore the potential of new identities, while others retain direct expressive styles such as swearing or other indirect styles for the expression of emotion” (2009, p. 84).

## Aging, media and corpora

Not surprisingly, stereotypical images of aging are “perpetuated by media ads and their potential influence on consumers’ perceptions and attitudes” (Zhang et al., 2006, p. 265). Newspapers often continue the stereotypes of aging as suggested by Fealy and McNamara (2009, p. 22), who examine two Irish newspapers, one a broadsheet and the other a tabloid. They find that older people’s identities are constructed within one of five types, viz. older people as ‘victims’, ‘frail, infirm and vulnerable’, ‘radicalised citizens’, ‘deserving old’ and ‘undeserving old’. These identities are interrelated textually, such that some were contingent on others. Mautner (2007, p. 55) explores the 57-million word corpus *Wordbanks Online* <<http://www.collins.co.uk/page/Wordbanks+Online>>, a subscription-based corpus service which includes newspapers, books, magazines, and broadcasts. Mautner identifies the complexities in the word “elderly” and the associations it invokes through its collocations with words such as *people*, *woman*, *disabled* or *man*. It shows itself (p. 59) “strongly associated with lexical items related to disability, care, victimhood and vulnerable social groups” as a “social rather than a chronological label” (p. 60), the latter of which is seen as undesirable.

The Internet provides an expanded range of media which offer new venues in which to explore aging from a sociopragmatic perspective, although it remains *terra nova*, with only a few studies focusing on some aspect of aging that move beyond simple reportage. Lin et al. (2004) examine discourse and identity presentation in an on-line discussion forum involving 550 older adults. Citing earlier work by Coupland N. et al. (1991), they identify

two processes through which older adults or their conversational partners make age identities salient. Age-categorization processes involved disclosing age by explicitly indicating age-related characteristics in talk. These processes include disclosing chronological age, age-related category/role references, and age-related experiences of illness and decline. Temporal framing refers to discursive strategies that locate events, persons, and the like within temporal space and, by implication, invoke the speaker’s own age. (2004, p. 236)

Harwood (2004) looks at different aspects of online identity – for example, how identity as a grandparent interacts with identity as an older adult in a sample of 40 personal websites taken from 334 grandparents’ websites linked through a web ring. Four themes showing how grandparents write about their grandchildren are seen in the postings on the websites: affiliation with them, pride in them, exchanges with them and distance from them. These references “automatically” invoke age because the discussion is about the much younger generation by the older (p. 312). In studying intergenerational interactions between older adults

and their younger instructor in a computer facility located in a senior center, Divita (2012, p. 585) finds that “age informs the construction of social meaning as both a chronological fact and a dynamic social category.” He underscores findings by Sankoff and Blondeau (2007) that people modify their linguistic repertoires as they age, particularly in terms of variables that index gender or social class (p. 588).

While the valuable studies of online behaviors published by the Pew Internet Trust are not presented through a sociolinguistic or sociopragmatic lens, their surveys and findings, such as their analysis of the digital divide among older Americans along educational and economic lines (Smith, 2014; cf. Nimrod, 2013), give further contextualization to studies such as Lin’s (2008) sensitive discussion of sociolinguistic marginalization of a monolingual older Taiwanese woman. Left out of family conversation and unable to understand the Mandarin used on television, her “largely silent stance was co-constructed” (p. 326) and her listening and speaking were disabled by “her family’s collaborative negligence” (p. 327). We are reminded of similar situations identified by de Bot and Makoni (2005) about older multilinguals who accompany their grown children to new countries (cf. Divita, 2014).

Finally, the Internet offers new research opportunities for the sociolinguistic study of language and aging. While there are numerous blogs targeting different aspects of aging or research on aging, and at least one study on how to predict age behavior in blogs (Rosenthal & McKeown, 2011), we have found but a few sociolinguistic studies of language and aging in blogs (see, for example, Nishimura 2014). Where aging is a focus, is in the form of new corpora specifically constructed to include older adults and in corpus-based studies such as Murphy (2010), which examines the intersection of gender and age. Murphy (2010, p. 33) draws on the Corpus of Age and Gender, a small corpus of 90,000 words collected in Ireland. It consists of Irish English casual conversations with the researcher, and includes 20 females and 20 males as two corpora, each divided into sub-corpora of speakers in their 20s, their 40s, and their 70s/80s. Murphy reports on age-constraints by gender on hedges, vague language (such as extenders), boosters, intensifiers, and taboo language, with the first four being typically claimed as characteristic of female language. However, word-based corpus-driven analyses show that adulthood is anything but homogenous (p. 205). For example there are life stage constraints on usage, such as the relatively lower use of hedging by the 70s–80s, perhaps because those who were recorded, avoided sensitive topics. By contrast, speakers in their 20s displayed a higher use of expletives (pp. 206–207).

The *UP* corpus at Berkeley (Gahl et al., 2012) is a set of time-aligned audio-files from Michael Apted’s “Up” documentaries showing speakers at seven-year intervals, now aged 21–49. *CorpAGEst* <<http://www.corpagest.org>>; <

adre.ucl.ac.be/browse/list\_fac/ILC/pending/10046855/en> is a collection of multimodal interviews with healthy older French speakers. At the time of writing, it included 144 hours of audio and 13.5 hours of audio-video interview and has been supporting discussions of pragmatics and of multimodal annotation (Bolly et al., 2015). The *Carolinas Conversations Collection* (CCC; <<http://carolina-conversations.musc.edu/>>) has two multiethnic cohorts in its password-protected site. Cohort One contains time-aligned audio and video of conversations with men and women who are 65 years and older. Members of this cohort have two conversational interviews, one with young clinical professionals, and one with community partners of similar age and ethnicity. Cohort Two comprises audio recorded conversations with men and women who are 65 years and older, with cognitive impairment, most frequently dementia of the Alzheimer's type. Members of this cohort may have one to ten conversations over time, with researchers and with student visitors to their residences. The CCC currently has over 100 conversational interviews mounted, and is uploading others on an ongoing basis (Pope & Davis, 2010). In addition, although a focus on aging is not their purview, some conversations with or between older persons may be found in the *Santa Barbara Corpus of Spoken American English* <<http://www.linguistics.ucsb.edu/research/santa-barbara-corpus>> and in *Talk Bank* <<http://talkbank.org>>, *MICASE*, the Michigan Corpus of Academic Spoken English <<http://quod.lib.umich.edu/m/micase/>> and *VOICE*, the Vienna-Oxford International Corpus of English as a Lingua Franca <[http://www.univie.ac.at/voice/page/corpus\\_availability](http://www.univie.ac.at/voice/page/corpus_availability)>. All links were current as of November, 2014, but links change as the Internet expands, and we recommend searching by corpus name as well as using the links.

We turn now to two case studies that can exemplify ways that the language of older people may be used in research. The first case study uses the language of older adults to add to our knowledge of the way extenders are used. The second case study considers how the language of older speakers can be used as part of a study of the development of a variety of English, in this case, New Zealand English.

### Case study 1. Use of extenders by older adults

Extenders stretch utterances to indicate that a list has more items than those mentioned: *Getting ready for the holiday dinner, Toby went to the store and bought apples, oranges, pecans, and things like that*. Extenders are often categorized as vague language and condemned as inappropriate. However they are an essential part of the glue of normal conversations. Although common in youth speech,

on which most sociolinguistic studies of extenders have been based, they are used throughout the lifespan. They continue to be used by people with dementia (Maclagan et al., 2008). The impaired speakers in Case Study one used extenders to elicit further talk from their conversation partners and apparently hoped to continue to be seen as competent conversationalists. We focus here on the use of general extenders in three New Zealand corpora held at the University of Canterbury: the Mobile Unit Archive (MU; speakers born 1851–1910), the Intermediate Archive (IA; speakers born 1890–1930), and the Canterbury Corpus (CC; speakers born 1930–1984).

This analysis is part of an ongoing study comparing features of speech by older persons in New Zealand and the US. It adds to our understanding of the frequency and functions of general extenders used by older speakers from different regional varieties of English. Tagliamonte and Denis (2010) drew on a sample of 43 speakers, 11 of whom were 60 and older, from the Toronto English Archive for a variation study on extenders. They presented an historical overview of extenders in terms of chronology of occurrence, register variation, and social factors as well as grammatical change. Palacios Martinez (2011) compared British teens from the COLT corpus of adolescent speech with adults drawn from the Diachronic Corpus of Present-Day Spoken English (DCPSE). He summarized research on teen extenders, finding that extenders typify spoken discourse; may be increasing in use; and are “generally more common in adults than in teenage language” (p. 2452) with the extenders used by the teenagers often used for marking social and group identity instead of contributing to lists and for expressing the speaker’s attitude (p. 2466).

For the NZ study, we examined the following extenders: *and things/stuff (like that)*; *and anything/everything like that*; *and that*; *and so forth*; *and so on*. Not surprisingly, context was found to affect extender use. For example, in the IA corpus, 77% of the speakers used extenders in responses to open-ended questions about early childhood. In addition, across all three corpora, more women than men used extenders, and women used more extenders overall, although the difference was not statistically significant. Interestingly, as in the Toronto study (Tagliamonte & Denis, 2010), specific extenders in NZ can apparently go out of fashion. *And that sort of thing* was used by speakers born before 1930, but rarely by speakers born after 1930. This finding is similar to Murphy’s for Irish English men (Murphy, 2010, pp. 106–107), in which *that (kind of thing)* is strongly present in speech of those in their 70s and 80s, who would have been born in the 1930s/1940s, but not for younger men. By contrast, Irish English women in their 40s are still using *that (kind of thing)* (Murphy, 2010, p. 93).

## Case study 2. Contribution of older speakers to the analysis of New Zealand English

In 1947 and 1948 Radio New Zealand sent a mobile recording unit around New Zealand to record pioneer reminiscences (see Gordon et al., 2004 for more details). From the perspective of a sociolinguist, one of the remarkable features of these recordings is that the broadcasters did not only record the 'important' people like mayors and chief executives. Rather, they recorded 'ordinary' people – school-teachers, farmers, gold miners – including some women and some Māori. Most of the speakers were older – some over 100 years old. All had good stories to tell.

The non-Māori recordings were analyzed by Gordon and her colleagues in their analysis of the development of New Zealand English (Gordon et al., 2004). The oldest speaker in the archive of recordings was born in 1851, just eleven years after the founding document for European settlement of New Zealand, the Treaty of Waitangi, was signed. The birthdates of the other speakers range up to 1910. They cover the period when the New Zealand accent developed and allowed linguists to trace its development. The oldest speakers in this archive do not have New Zealand accents. Mrs. Cross, for example, was born in Dunedin in 1851, and speaks exactly as her Scottish parents would have done. The parents of Mr. Hovell (born 1855) both came from England, but his mother died when he was young and he was brought up by their Irish washerwoman. Not surprisingly, he acquired her Irish accent. These two speakers are typical of the oldest speakers in the archives. Some early NZ towns were settled by people from one area of Great Britain. For example, Milton in the South Island, was named for its woolen mill. The people in Milton came from similar areas in Scotland, and interacted mainly with each other. Even second-generation Milton residents whose parents were both born in New Zealand do not have noticeable New Zealand accents. They pronounce post-vocalic (r) in words like *farm* where modern New Zealand English is non-rhotic and only pronounces (r) before a following vowel. The speakers in other relatively isolated New Zealand towns where all the settlers came from the one area similarly retain strong traces of their parents' accents.

Gold was discovered in Gabriel's Gully in 1861. This led to an influx of miners from different parts of the world. Towns like Cromwell and Arrowtown in the South Island or Coromandel in the North Island were filled with people from different parts of England as well as Scotland and Ireland, including miners who had been part of the gold rushes in Australia and California. In the melting pots of the gold camps, but not in the towns where everyone came from similar parts of Great Britain, the extremes of people's accents were modified in the interests of communication. A distinctive New Zealand accent can first be heard in speakers from these towns. Mrs. Annie Hamilton, for instance, was born in Arrowtown in

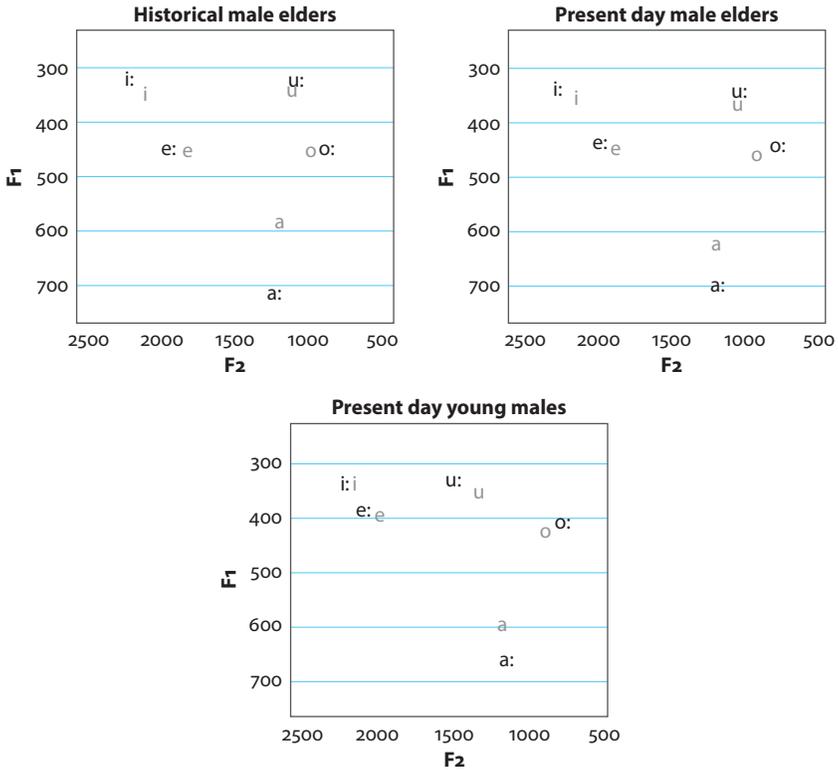
1877. Both her parents came from Ireland, but she sounds like a New Zealander. Similarly, Mrs. Catherine Dudley was born in 1886. Her mother came from Scotland and her father from Ireland, but she also has a marked New Zealand accent. New Zealand English is the only native speaker variety of English for which we have recordings that cover the whole of its history. Without these older speakers it would not have been possible to trace the history and development of New Zealand's distinctive accent.

The Māori speakers recorded by the Mobile Unit formed the basis of the Māori and New Zealand English project (MAONZE), which has studied the development of the pronunciation of the Māori language, the language of the indigenous people of New Zealand. The MAONZE database also includes ten recordings of older speakers born approximately 50 years after the historical speakers and ten younger speakers born approximately 50 years later still. It also includes parallel recordings of women speakers. These recordings allow the MAONZE study group to trace the development of Māori pronunciation from early contact with Europeans in the 1800s to the present day. Copyright for the Mobile Unit material is held by Radio NZ Archives, Ngā Taonga Sound and Vision. Copies of the recordings are held at the University of Canterbury.

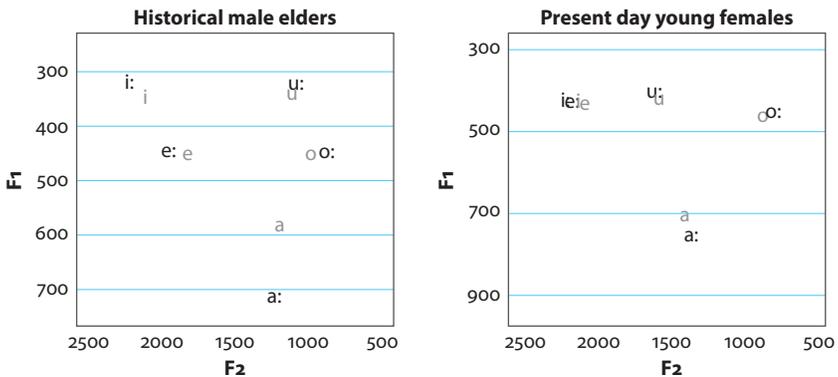
The men and women born in the late 1800s (the historical elders) provided an indication of the pronunciation of Māori before it was heavily influenced by English. Māori is a Polynesian language, and scholars consider that the Polynesian five vowel system, /i, e, a, o, u/, has remained basically unchanged for 10,000 years (Krupa, 1982). However there have been great changes in Māori in the 160 years since European settlement in New Zealand. The five vowels of Māori occur in long and short contrastive pairs and lower and higher vowels combine to form diphthongs (King et al., 2009). Figure 1 shows the vowel spaces of the three groups of male speakers. The vowel space of the historical male elders on the top left of Figure 1 shows the vowels distributed evenly around the vowel quadrilateral. In particular /u:/ and /u/ are back vowels and /e:, e, o:, o/ are mid in height. The only short/long vowel pair for which there has historically been a difference in quality is /a~a:/ (Bauer, 1993). This can be seen with /a/ much closer to the centre of the vowel space than /a:/.

Change can be seen in the vowels of the present day elders in the top right of Figure 1. The mid vowels have started to raise, /u:/ and /u/ have started to front and /a/ has lowered so it is closer to /a:/. Change is more obvious for the young males. The mid vowels have continued to raise and /u:/ and /u/ are nearly as central as they are in modern New Zealand English (Gordon et al., 2004).

Women are ahead of the men in all the sound changes analyzed by the MAONZE team (see King et al., 2010). Figure 2 contrasts the vowels of the historical male elders from Figure 1 with those of the present day young females.



**Figure 1.** Long and short vowel F1 and F2 means of the Māori speech of the historical male elders, the present day male elders and the present day young males. Formant values are shown in Hz. (From King et al., 2011)



**Figure 2.** Long and short vowel F1 and F2 means of the Māori speech of historical male elders and present day young females. Formant values are shown in Hz. (From King et al., 2011). Different scales are used on the y-axes to compensate for the different sizes of men's and women's vocal tracts.

The changes that could be seen over time with the males are even more marked with the young females. /u:/ and /u/ are now completely centralized, and the mid vowels, /e:/, e, o:/, o/, have raised so that they are now high vowels. /e:/ and /e/ completely overlap the acoustic space of /i:/ and /i/. Without the recordings of the historical speakers and the present day elders, the extent of the change in the pronunciation of Māori could not have been analyzed. For Māori, as well as New Zealand English, the contribution of older speakers has been essential for an analysis of the way its pronunciation has changed over time.

## Summary and implications

This short review has, of necessity, omitted work by a number of fine scholars, in its effort to highlight current trends in sociolinguistic and sociopragmatic studies focused on language and aging. As noted earlier,

we cannot always confidently disentangle an approach focused on interpersonal pragmatics from one that is focused on interactional sociolinguistics, and it may be that the two approaches are closer than practitioners from either perspective have realized. (Davis 2010, p. 381)

In our introduction, we used illustrations from studies of language change in well-known persons to contextualize the realization in cultural studies that languages change over time and that the language of and about aging are both important constructs in understanding cultural currents. We highlighted several recent clinical studies whose findings are of interest to sociolinguistic studies of (narrative) gist, politeness, and fillers. We attempted to summarize the voluminous literature on language change in sociolinguistic language variation studies. In this literature, we focused on issues which complicate and even interrogate sociolinguistics' usual emphasis on single-variable studies intersecting with specific age cohorts. We then briefly referenced studies in sociophonetics. Since much of discourse analysis from a sociolinguistic/sociopragmatic perspective focuses on identities and on gender, we highlighted a selected number of studies and overviews that seem to us to be representative of current intersections of language use with aging.

The Internet, with its range of media, offers further complications to studies of language, aging, identities, gender and language change. However, with the development of available machine-readable corpora of oral and written texts, the Internet also offers new resources for the study of these areas. Our two case studies were designed to illustrate how the language of older adults has been essential in analyzing the development of language within two varieties of English. These studies would not have been possible without the presence of older adults in the

corpora on which they were based. Throughout, we have tried to emphasize the growing, considerable impact of both communication studies and gerontology on our knowledge of language and aging. We conclude with a call for further interdisciplinary collaboration among these areas, joined whenever possible to the cognitive issues more often identified in clinical linguistics.

## References

- Abe, J. (2011). Changes in Alan Greenspan's language use across the economic cycle: A text analysis of his testimonies and speeches. *Journal of Language and Social Psychology*, 30, 212–223. doi:10.1177/0261927X10397152
- Bamberg, M., De Fina, A., & Schiffrin, D. (2011). Discourse and identity construction. In S. Schwartz, K. Luyckx & V. Vignoles (Eds.), *Handbook of identity theory and research* (pp. 177–199). New York, NY: Springer. doi:10.1007/978-1-4419-7988-9\_8
- Bauer, W. (1993). *Māori*. London: Routledge. doi:10.4324/9780203403723
- Bolly, C. T. & Thomas, A. (2015). Facing Nadine's speech. Multimodal annotation of emotion in later life. In K. Jokinen & M. Vels (Eds.), *Proceedings of the 2nd European and the 5th Nordic Symposium on Multimodal Communication August 6-8, Tartu, Estonia*. Linköping: Linköping Electronic Conference Proceedings 110, 23–32. Retrieved from: <<https://www.uclouvain.be/281511.html#CV>>
- Brown, C., Snodgrass, T., Kemper, S., Herman, R., & Covington, M. (2008). Automatic measurement of propositional density from part-of-speech tagging. *Behavior Research Methods*, 40, 540–545. doi:10.3758/BRM.40.2.540
- Cameron, R. (2005). Aging and gendering. *Language in Society*, 34, 23–61. doi:10.1017/S0047404505050025
- Cameron, R. (2011). Aging, age, and sociolinguistics. In M. Diaz-Campos (Ed.), *The handbook of Hispanic sociolinguistics* (pp. 207–229). Malden, MA: Wiley-Blackwell
- Chand, V., & Bonnici, L. (2010). Applied linguistics: The import of sociolinguistics for medical research. *New Ways of Analyzing Variation (NWAV-39)*, San Antonio, TX, November 4–6. Retrieved from: <<http://colfa.utsa.edu/nwav39/talks/ChandBonnici.pdf>>
- Chand, V., Baynes, K., Bonnici, L., & Farias, S. (2012). A rubric for extracting idea density from oral language samples. *Current Protocols in Neuroscience*, ch. 10. doi:10.1002/0471142301.n51005558
- Chapman, S., & Mudar, R. (2013). Discourse gist: A window into the brain's complex cognitive capacity. *Discourse Studies*, 15, 519–533. doi:10.1177/1461445613501444
- Charteris-Black, J., & Seale, C. (2009). Men and emotion talk: Evidence from the experience of illness. *Gender and Language*, 3, 81–113. doi:10.1558/genl.v3i1.81
- Cheshire, J. (2008). Age and generation-specific use of language. Retrieved from: <<http://web-space.qmul.ac.uk/jlcheshire/sociolingx%20and%20age.pdf>>
- Coulmas, F., & Backhaus, P. (2009). Introduction: Aging and language. *International Journal of the Society of Language*, 200, 5–10.
- Coupland, J. (2009a). Time, the body and the reversibility of ageing: Commodifying the decade. *Ageing in Society*, 29, 953–976. doi:10.1017/S0144686X09008794

- Coupland, J. (2009b). Discourse, identity and change in mid-to-late life: Interdisciplinary perspectives on language and ageing. *Ageing in Society*, 29, 848–861.
- Coupland, J. (2013). Dance, ageing and the mirror: Negotiating watchability. *Discourse and Communication*, 7, 3–24. doi:10.1177/1750481312466477
- Coupland, N. (1997). Language, ageing and ageism: A project for applied linguistics? *International Journal of Applied Linguistics*, 7(1), 26–48. doi:10.1111/j.1473-4192.1997.tb00102.x
- Coupland, N. (2004). Age in social and sociolinguistic theory. In J. Nussbaum & J. Coupland (Eds.), *Handbook of communication and aging research*, (2nd ed.; pp. 69–90). Mahwah, NJ: Lawrence Erlbaum Associates.
- Coupland, N., & Bishop, H. (2009). Ideologised values for British accents. In N. Coupland & A. Jaworski (Eds.), *Sociolinguistics: Critical concepts in linguistics, Vol. II: Subjective and ideological processes* (pp. 18–43). Oxford: Routledge.
- Coupland, N., Coupland, J., & Giles, H. (1991a). *Language, society and the elderly: Discourse, identity and ageing*. Cambridge, MA: Blackwell.
- Coupland, N., Coupland, J., & Giles, H. (1991b). *Contexts of accommodation: Developments in applied sociolinguistics*. Cambridge: Cambridge University Press.  
doi:10.1017/CBO9780511663673
- Davis, B. (Ed.). (2005). *Alzheimer talk, text and context: Enhancing communication*. New York, NY: Palgrave Macmillan. doi:10.1057/9780230502024
- Davis, B. (2010). Interpersonal issues in health discourse: Caregiver-resident interaction in Alzheimer talk. In M. Locher & S. Graham (Eds.), *Interpersonal pragmatics* (pp. 381–404). Berlin: Mouton de Gruyter.
- Davis, B., & Bernstein, C. (2005). Talking in the here and now: reference and narrative in Alzheimer conversation. In B. Davis, (Ed.), *Alzheimer talk, text and context* (pp. 60–86). New York, NY: Palgrave. doi:10.1057/9780230502024
- Davis, B., & Guendouzi, J. (Eds.). (2014). *Pragmatics in dementia discourse*. Newcastle-upon-Tyne: Cambridge Scholars.
- Davis, B., Maclagan, M., & Cook, J. (2014). ‘Aw, so, how’s your day going?’: Ways that persons with dementia keep their conversational partner involved. In B. Davis & J. Guendouzi (Eds.), *Pragmatics in dementia discourse* (pp. 83–116). Newcastle-upon-Tyne: Cambridge Scholars.
- de Bot, K., & Makoni, S. (2005). *Language and aging in multilingual contexts*. Clevedon: Multilingual Matters.
- De Fina, Anna. (2006). Group identity, narrative and self-representations. In A. De Fina, D. Schiffrin, & M. Bamberg (Eds.), *Discourse and identity* (pp. 351–374). Cambridge: Cambridge University Press. doi:10.1017/CBO9780511584459.018
- De Fina, A. (2013). Discourse and identity. In T. Van Dijk (Ed.), *Discourse studies: A multidisciplinary introduction* (2nd ed.; pp. 263–282). Thousand Oaks, CA: Sage.
- De Fina, A., & Georgakopoulou, A. (2008). Introduction: Narrative analysis in the shift from texts to practices. *Text and Talk*, 28, 275–281. doi:10.1515/TEXT.2008.013
- De Fina, A., & Georgakopoulou, A. (2012). *Analyzing narrative: Discourse and sociolinguistic perspectives*. Cambridge: Cambridge University Press.
- Divita, D. (2012). Online in later life: Age as a chronological fact and a dynamic social category in an Internet class for retirees. *Journal of Sociolinguistics*, 16, 585–612.  
doi:10.1111/josl.12000
- Divita, D. (2014). Multilingualism and later life: A sociolinguistic perspective on age and aging. *Journal of Aging Studies*, 30, 94–103. doi:10.1016/j.jaging.2014.04.002

- Eckert, P. (1997). Age as a sociolinguistic variable. In F. Coulmas (Ed.), *Handbook of sociolinguistics* (pp. 151–167). Oxford: Blackwell.
- Eckert, P. (2012). Three waves of variation study: The emergence of meaning in the study of sociolinguistic variation. *Annual Review of Anthropology*, 41, 87–100.  
doi:10.1146/annurev-anthro-092611-145828
- Eckert, P., & McConnell-Ginet, S. (2003). *Language and gender*. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511791147
- Fealy, G., & McNamara, M. (2009). *Constructing ageing and age identity: A case study of newspaper discourses*. Dublin: National Centre for the Protection of Older People (NCPOP). Retrieved from: <<http://www.ncpop.ie/userfiles/file/ncpop%20reports/Study%201%20DA%20ageing.pdf>>
- Ferguson, A., Spencer, E., Craig, H., & Colyvas, K. (2014). Propositional idea density in women's written language over the lifespan: Computerized analysis. *Cortex*, 55, 107–121.  
doi:10.1016/j.cortex.2013.05.012
- Foulkes, P., Scobbie, J., & Watt, D. (2010). Sociophonetics. In W. Hardcastle, J. Laver, & F. Gibbon (Eds.), *The handbook of phonetic sciences* (2nd ed.; pp. 703–754). Malden, MA: Blackwell. doi:10.1002/9781444317251.ch19
- Gahl, S., Hall, K., Cibelli, E., & Sprouse, R. (2012). The “Up” corpus: A corpus of speech samples across adulthood [Berkeley Phonology Lab Annual Report]. Retrieved from: <<http://www.linguistics.berkeley.edu/~gahl/upInPress.pdf>>
- Garrard, P., Maloney, L., Hodges, J., & Patterson, K. (2005). The effects of very early Alzheimer's disease on the characteristics of writing by a renowned author. *Brain*, 128, 250–260.  
doi:10.1093/brain/awh341
- Georgakopoulou, A. (2006). Small and large identities in narrative (inter)action. In A. De Fina, D. Schiffrin, & M. Bamberg (Eds.), *Discourse and identity* (pp. 83–102). Cambridge: Cambridge University Press. doi:10.1017/CBO9780511584459.005
- Georgakopoulou, A., & Charalambidou, A. (2011). Doing age and ageing: Language, discourse and social interaction. In K. Aijmer & G. Andersen (Eds.), *Pragmatics of society* (pp. 31–51). Berlin: Mouton de Gruyter.
- Gist, Y., & Velkoff, V. (1997). Gender and aging: Demographic dimensions. (International Brief No. IB/97-3). U.S. Department of Commerce Economics and Statistics Administration. Retrieved from: <<https://www.census.gov/population/international/files/ib-9703.pdf>>
- Gordon, E., Campbell, L., Hay, J., Maclagan, M., Sudbury, A., & Trudgill, P. (2004). *New Zealand English: Its origins and evolution*. Cambridge: Cambridge University Press.  
doi:10.1017/CBO9780511486678
- Guendouzi, J., & Mueller, N. (2005). *Approaches to discourse in dementia*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Hamilton, H. (1994). *Conversations with an Alzheimer's patient*. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511627774
- Hamilton, H. (Ed.). (1999). *Language and communication in old age: Multidisciplinary perspectives*. New York, NY: Garland.
- Hamilton, H. (2000). Dealing with declining health in old age: Identity construction in the Oppen family letter exchange. In J. Peyton, P. Griffin, W. Wolfram, & R. Fasold (Eds.), *Language in action: New studies of language in society* (pp. 599–610). Cresskill, NJ: Hampton Press.
- Hamilton, H. (2001). Discourse and aging. In D. Schiffrin, D. Tannen, & H. Hamilton (Eds.), *The handbook of discourse analysis* (pp. 568–589). Malden, MA: Blackwell.

- Hamilton, H. (2008). Language and dementia: Sociolinguistic aspects. *Annual Review of Applied Linguistics*, 28, 91–110. doi:10.1017/S0267190508080069
- Harrington J., Palethorpe, S., & Watson, C. (2000). Monophthongal vowel changes in received pronunciation: An acoustic analysis of the Queen's Christmas broadcasts. *Journal of the International Phonetic Association*, 30, 63–78. doi:10.1017/S0025100300006666
- Harwood, J. (2004). Relational, role, and social identity as expressed in grandparents' websites. *Communication Studies*, 55, 300–318. doi:10.1080/10510970409388621
- Holtgraves, T., & McNamara, P. (2010). Parkinson's disease and politeness. *Journal of Language and Social Psychology*, 29, 178–193. doi:10.1177/0261927X09359521
- Kemper, S., & Anagnopoulos, C. (1989). Language and aging. *Annual Review of Applied Linguistics*, 10, 37–50. doi:10.1017/S0267190500001203
- Kemper, S., Greiner, L., Marquis, J., Prenovost, K., & Mitzner, T. (2001). Language decline across the life span: Findings from the Nun Study. *Psychology and Aging*, 16, 227–239. doi:10.1037/0882-7974.16.2.227
- King, J., Harlow, R., Watson, C., Keegan, P., & Maclagan, M. (2009). Changing pronunciation of the Māori language: Implications for revitalization. In J. Reyhner & L. Lockard (Eds.), *Indigenous language revitalization: Encouragement, guidance & lessons learned* (pp. 85–96). Flagstaff, AZ: Northern Arizona University.
- King, J., Watson, C., Maclagan, M., Harlow, R., & Keegan, P. (2010). Māori women's role in sound change. In J. Holmes & M. Marra (Eds.), *Femininity, feminism and gendered discourse* (pp. 191–211). Newcastle-upon-Tyne: Cambridge Scholars.
- King, J., Maclagan, M., Harlow, R., Keegan, P., & Watson, C. (2011). The MAONZE corpus: transcribing and analysing Māori speech. *New Zealand Studies in Applied Linguistics*, 17, 32–48.
- Krupa, V. (1982). *The Polynesian languages: A guide* (Languages of Asia and Africa, 4). London: Routledge and Kegan Paul.
- Kwan, S. (2014). Vowel change across Noam Chomsky's lifespan. *University of Pennsylvania Working Papers in Linguistics*, 20(2), 91–100. Retrieved from: <<http://repository.upenn.edu/pwpl/vol20/iss2/11/>>
- Labov, W. (1972). The social stratification of (r) in New York City department stores. In W. Labov (Ed.), *Sociolinguistic patterns* (pp. 168–172). Philadelphia, PA: University of Pennsylvania Press.
- Labov, W. (2006). A sociolinguistic perspective on sociophonetic research. *Journal of Phonetics*, 34, 500–515. doi:10.1016/j.wocn.2006.05.002
- Lancashire, I., & Hirst, G. (2009). Vocabulary changes in Agatha Christie's mysteries as an indication of dementia: A case study. Paper Presented at the *19th Annual Rotman Research Institute Conference, Cognitive Aging: Research and Practice*. Toronto, Canada. Retrieved from: <<http://homes.chass.utoronto.ca/~ian/>>
- Le, X., Lancashire, I., Hirst, G., & Jokel, R. (2011). Longitudinal detection of dementia through lexical and syntactic changes in writing: A case study of three British novelists. *Literary and Linguistic Computing*, 26, 435–461. doi:10.1093/lc/fqr013
- Lin, M., Hummert, M., & Harwood, J. (2004). Representation of age identities in on-line discourse. *Journal of Aging Studies*, 18, 261–274. doi:10.1016/j.jaging.2004.03.006
- Lin, S. (2008). How listening is silenced: A monolingual Taiwanese elder constructs identity through television viewing. *Language in Society*, 38, 311–337. doi:10.1017/S0047404509090514

- Maclagan, M., Davis, B., & Lunsford, R. (2008). Fixed expressions, extenders and metonymy in the speech of people with Alzheimer's Disease. In S. Granger & F. Meunier (Eds.), *Phraseology: An interdisciplinary perspective* (pp. 175–186). Amsterdam: John Benjamins.  
doi:10.1075/z.139.17mac
- Mather, P. (2012). The social stratification of /r/ in New York City: Labov's department store study revisited. *Journal of English Linguistics*, 40, 338–356. doi:10.1177/0075424211431265
- Matsumoto, Y. (2009). Dealing with changes – Humorous self-disclosure by elderly Japanese women. *Ageing and Society*, 29, 929–952. doi:10.1017/S0144686X0900885X
- Matsumoto, Y. (2011a). Painful to playful: Quotidian frames in the conversational discourse of older Japanese women. *Language in Society*, 40(5), 591–616.  
doi:10.1017/S0047404511000698
- Matsumoto, Y. (2011b). Reframing to regain identity with humor: What conversations with friends suggest for communication in elderly care. In P. Backhaus (Ed.), *Communication in elderly care* (pp. 145–165). London: Continuum.
- Mautner, G. (2007). Mining large corpora for social information: The case of elderly. *Language in Society*, 36, 51–72. doi:10.1017/S0047404507070030
- McConnell-Ginet, S. (2003). What's in a name? Social labeling and gender practices. In J. Holmes & M. Meyerhoff (Eds.), *Handbook of language and gender* (pp. 69–97). Malden, MA: Blackwell. doi:10.1002/9780470756942.ch3
- Mortensen, L., Meyer, A., & Humphreys, G. (2006). Age-related effects on speech production: A review. *Language and Cognitive Processes*, 21, 238–290. doi:10.1080/01690960444000278
- Murphy, B. (2010). *Corpus and sociolinguistics: Investigating age and gender in female talk*. Amsterdam: John Benjamins. doi:10.1075/scl.38
- Nikander, P. (2009). Doing change and continuity: Age identity and the micro-macro divide. *Ageing and Society*, 29, 863–881. doi:10.1017/S0144686X09008873
- Nimrod, G. (2013). Probing the audience of seniors' online communities. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*, 68, 773–782.  
doi:10.1093/geronb/gbt059
- Nishimura, Y. (2014). Stylistic variation of gender and age in blog posts in Japan: From a Perspective on third age research. *Conference paper abstract for N WAV 43, Chicago IL*. Retrieved from: <<http://www.nwav43.illinois.edu/program/documents/Nishimura-LongAbstract.pdf>>
- Norrick, N. (2009). The construction of multiple identities in elderly narrators' stories. *Ageing and Society*, 29, 903–927. doi:10.1017/S0144686X09008599
- Nussbaum, J., & Coupland, J. (2004). *Handbook of communication and aging research* (2nd ed.). Mahwah, NJ: Lawrence Erlbaum Associates.
- Oberman, L., & Pascual-Leone, A. (2013). Changes in plasticity across the lifespan: Cause of disease and target for intervention. *Progress in Brain Research*, 207(4), 91–120.  
doi:10.1016/B978-0-444-63327-9.00016-3
- Palacios Martinez, I. (2011). 'I might, I might go I mean it depends on money things and stuff': A preliminary analysis of general extenders in British teenagers' discourse. *Journal of Pragmatics*, 43, 2452–2470. doi:10.1016/j.pragma.2011.02.011
- Pope, C., & Davis, B. (2010). Finding a balance: The Carolinas Conversation Collection. *Corpus Linguistics and Linguistic Theory*, 7, 143–161.
- Ramanathan, V. (1995). Narrative well-formedness in Alzheimer's discourse: An interactional examination across settings. *Journal of Pragmatics*, 23, 395–419.  
doi:10.1016/0378-2166(94)00047-1

- Ramanathan, Vai. (1997). *Alzheimer discourse: Some sociolinguistic dimensions*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Rosenthal, S., & McKeown, K. (2011). Age prediction in blogs: A study of style, content, and online behavior in pre- and post-social media generations. Paper Presented at the *Proceedings of the 49th Annual Meeting of the Association for Computational Linguistics* (pp. 763–772). Portland, OR.
- Sankoff, G., & Blondeau, H. (2007). Language change across the lifespan: /r/ in Montreal. *Language*, 83, 60–588. doi:10.1353/lan.2007.0106
- Schiffrin, D. (2000). Mother/daughter discourse in a Holocaust oral history. *Narrative Inquiry*, 10, 1–44. doi:10.1075/ni.10.1.01sch
- Schiffrin, D. (2001a). Language, experience and history: ‘What happened’ in World War II. *Journal of Sociolinguistics*, 5, 323–352. doi:10.1111/1467-9481.00153
- Schiffrin, D. (2001b) Language and public memorial: ‘America’s concentration camps. *Discourse and Society*, 12, 505–534. doi:10.1177/0957926501012004005
- Schiffrin, D. (2002). Mother and friends in a Holocaust survivor oral history. *Language in Society*, 31, 309–354. doi:10.1017/S0047404502020250
- Schrauf, R., & Mueller, N. (Eds.). (2014). *Dialogue and dementia: Cognitive and communicative resources for engagement*. New York, NY: Psychology Press.
- Seale, C., & Charteris-Black, J. (2008). The interaction of age and gender in illness narratives. *Ageing and Society*, 28, 1025–1045. doi:10.1017/S0144686X0800737X
- Shafto, M., & Tyler, L. (2014). Language in the aging brain: The network dynamics of cognitive decline and preservation. *Science*, 346(6209), 583–587. doi:10.1126/science.1254404
- Smith, A. (2014). Older adults and technology use. Pew Research Internet Project. Retrieved from: <<http://www.pewinternet.org/2014/04/03/older-adults-and-technology-use/>>
- Snowdon, D., Kemper, S., Mortimer, J., Griner, L., Wekstein, D., & Markesbery, W. (1996). Linguistic ability in early life and cognitive function and Alzheimer’s disease in late life: Findings from the Nun Study. *JAMA*, 275, 528–532. doi:10.1001/jama.1996.03530310034029
- Tagliamonte, S., & Denis, D. (2010). The stuff of change: General extenders in Toronto, Canada. *Journal of English Linguistics*, 38, 333–368. doi:10.1177/0075424210367484
- Thomas, E. (2011). *Sociophonetics*. New York, NY: Palgrave.
- Venneri, A., Forbes-McKay, K., & Shanks, M. (2005). Impoverishment of spontaneous language and the prediction of Alzheimer’s disease. *Brain*, 128, 128–129. doi:10.1093/brain/awh419
- Wagner, S. (2012). Age grading in sociolinguistic theory. *Language and Linguistics Compass*, 6, 371–382. doi:10.1002/lnc3.343
- Walker, A. (2007). The effect of phonetic detail on perceived age and social class. Paper Presented at the *International Congress of Phonetic Sciences XVI*, Saarbrücken, Germany. Retrieved from: <[www.icphs2007.de](http://www.icphs2007.de)>
- Zhang, Y., Harwood, J., Williams, A., Ylanne-McEwen, V., Wadleigh, P., & Thimm, C. (2006). Portrayal of older adults in advertising: A cross-national review. *Journal of Language and Social Psychology*, 25, 264–282. doi:10.1177/0261927X06289479



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Age-related changes in cognitive and language functions have been extensively researched over the past half-century. The older adult represents a unique population for studying cognition and language because of the many challenges that are presented with investigating this population, including individual differences in education, life experiences, health issues, social identity, as well as gender. The purpose of this book is to provide an advanced text that considers these unique challenges and assembles in one source current information regarding (a) language in the aging population and (b) current theories accounting for age-related changes in language function. A thoughtful and comprehensive review of current research spanning different disciplines that study aging will achieve this purpose. Such disciplines include linguistics, psychology, sociolinguistics, neurosciences, cognitive sciences, and communication sciences.

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