CONSCIOUS AND UNCONSCIOUS MENTALITY

Examining their Nature, Similarities and Differences

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TEMPLATE TUNING AND GRADED CONSCIOUSNESS

Berit Brogaard and Thomas Alrik Sørensen

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14.1 Introduction

Whether visual perceptual consciousness is gradable or dichotomous has been the subject of fierce debate in recent years (e.g., Sergent and Dehaene 2004; Eiserbeck et al. 2022). To see what is at stake, it will be helpful to introduce Ned Block's (1995; 2005; 2007) distinction between access consciousness and phenomenal consciousness. According to this distinction, a perceptual state is phenomenally conscious (or P-conscious) when the perceiver is subjectively (or phenomenally) aware of what is represented by the state. By contrast, a perceptual state is access-conscious (or A-conscious) when its representational content is accessible to the perceiver for post-perceptual tasks such as verbal reports, reasoning, and action planning. It is generally agreed that, for the content of a perceptual state to be accessible to the perceiver it must be represented in working memory (Baars 1997; Baddeley 2012), or in another perceptual memory store like visual short-term memory (Sørensen and Kyllingsbæk 2012). In spite of the fact that P- and A-consciousness are distinct conceptual constructs, the received view in philosophy and psychology is that they actually co-occur and thus are important characteristics of the same phenomenon (Brogaard 2011a; 2011b). Assuming the latter view, the hypothesis that perceptual consciousness is dichotomous holds that a perceiver has full access to (i.e., is A-conscious of), and thus is fully phenomenally aware of (i.e., is P-conscious of) perceptual information that is represented in some memory store (e.g., visual). By contrast, the hypothesis that perceptual consciousness is gradable holds that a perceiver may have less than full access to—and thus be less than fully phenomenally aware of—perceptual information that is

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represented in working memory. This raises a question: In virtue of what can a subject be less than fully A- and P-conscious of perceptual information? In this chapter, we provide an answer to this question, according to which inexact categorizations of visual input may result in a representation of the visual information in working memory that is less than fully available to the perceiver, and of which the perceiver therefore is less than fully phenomenally aware. The latter proposal is a natural extension of a theory of perception we have proposed in previous works, namely, the template tuning theory (TTT; Brogaard and Sørensen 2023, *in press a, b*). We argue that TTT is compatible with both a gradable and a dichotomous conception of perceptual consciousness, but suggest that the available empirical evidence favours the view that perceptual consciousness is a graded phenomenon.

14.2 Graded consciousness

The question arises as to what we might mean by "degraded consciousness." What we are interested in here is the A- and P-consciousness associated with (visual) perceptual experience, or perceptual A- and P-consciousness for short. On a common conception of perceptual consciousness, degraded perceptual P-consciousness is associated with reduced visibility or visual clarity of what is perceptually represented, whereas degraded A-consciousness is associated with reduced cognitive access to the perceptual information available for visual working memory (VWM) tasks (Brogaard 2018). One phenomenon that intuitively leads to degraded perceptual A- and P-consciousness is reduced signal acuity with respect to stimulus features, such as shape and texture. Reduced signal acuity (or resolution) can occur as a result of suboptimal viewing conditions, physiological, and neurophysiological abnormalities in the visual system, or less than full allocation of cognitive resources (e.g., attention).[1] For example, in the street scene in Figure 14.1, the reduced visibility and the reduced availability of exact spatial information makes it difficult to identify the objects making up the scene. However, scene context can aid identification. For example, the "car" on the left is identical to the "pedestrian" on the right after 90-degrees rotation (Oliva and Torralba 2007). Yet, we are able to recognize these objects by relying on the scene context.

Reduced attention can also intuitively lead to degraded perceptual consciousness (Brogaard 2015).[2] For example, when focusing your attention on the fixation point between the two Gabor patches in Figure 14.2, the two gradients appear to have different spatial resolutions (or texture), but when you covertly attend (without moving your eyes) to the left patch, the two gradients appear to have the same spatial resolution.

In line with these intuitive examples of degraded consciousness, experimental approaches to test whether consciousness is graded have aimed

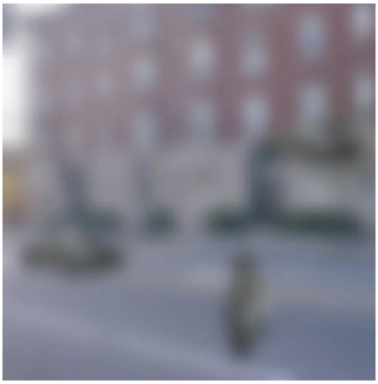

FIGURE 14.1 Reduced spatial acuity. In this image, the "pedestrian" on the right is identical to the "car" on the left after 90 degrees rotation, making scene context essential to object identification.

Source: From Oliva and Torralba 2007.

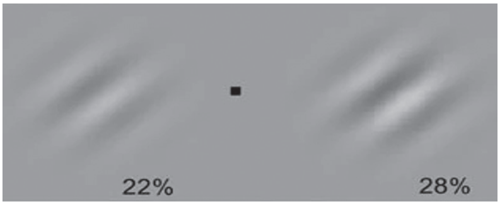

FIGURE 14.2 If you attend to the fixation point, the two patches appear to have different spatial resolutions compared to if you fixate to the fixation point but covertly attend to the left patch.

Source: From Carrasco et al. 2004.

to modulate A-consciousness, combined with a measure of P-consciousness, by manipulating either the visual input (e.g., backward masking, low contrast) or the allocation of cognitive resources (e.g., attentional blink; AB; Raymond et al. 1992).

The gold standard for determining whether P-consciousness is graded is the perceptual awareness scale (PAS) (Ramsøy and Overgaard 2004; cf. Overgaard and Sørensen 2004, Overgaard et al. 2006, combining PAS with introspection). In PAS, participants are first presented with a series of visual stimuli and then asked to evaluate the subjective visibility or visual clarity of their perceptual experiences on a four-point scale: "clear image," "almost clear image," "weak glimpse," and "not seen."

Finally, some studies have used electrophysiological (EEG) recordings to measure whether graded modulations of A-consciousness result in a corresponding modulation of event-related brain potentials (ERPs) that have been proposed as markers of A- or P-consciousness (e.g., Tagliabue et al. 2016). Proposed ERP markers of A- or P-consciousness include P1, P3, N1, N2, and N3 (Koivisto and Revonsuo 2003; Pins and ffytche 2003; Wilenius and Revonsuo 2007; Koivisto et al. 2008). In a comprehensive review of EEG studies of visual consciousness, however, Koivisto and Revonsuo (2010) found that the most reliable and most consistently observed ERP marker of visual consciousness is the "visual awareness negativity" (VAN) effect, an early-to-late negative wave deflection at posterior or anterior recording sites, with peak latency around 200–450 ms after stimulus onset, thus overlapping N1–N2 (Figure 14.3). The VAN effect is usually followed by a long-lasting P3 or late positive (LP) effect over the parietal lobes around 400 ms after stimulus onset. The correlation with visual consciousness of both VAN and LP has led some authors to suggest that VAN is an electrophysiological correlate of P-consciousness, whereas LP is a correlate of A-consciousness (Tagliabue et al. 2016). However, several studies have observed LP only for task-relevant/reported stimuli, suggesting that this component may be marker of post-perceptual processing rather than A-consciousness (e.g., Koivisto and Revonsuo 2007; 2010; Pitts et al. 2012; Koch et al. 2016; Cohen et al. 2020). For example, LP has been found to co-vary with subjects' confidence in their perceptual judgements (Koivisto and Revonsuo 2010). Likewise, early positive components like the P1 are not markers of consciousness, as physical properties of the stimulus (e.g., luminance contrast) can elicit P1, regardless of whether it is encoded in VWM.

A large body of experiments has provided support for the hypothesis that consciousness is graded. The studies manipulating the visibility of the stimulus

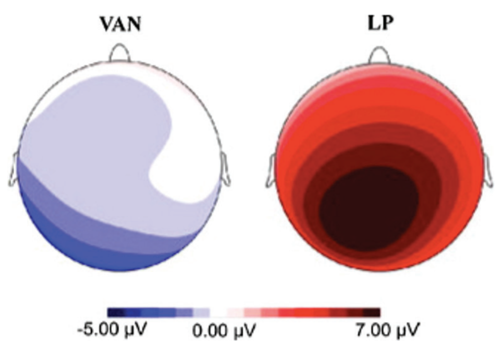

FIGURE 14.3 The typical scalp distribution of the VAN effect, the most consistent marker of visual consciousness, and the LP effect, a likely marker of post-perceptual processing.

Source: From Koivisto and Revonsuo 2010.

using backward masking, combined with a visibility measure, have shown that mean visibility ratings follow either a gradable pattern (e.g., Ramsøy and Overgaard 2004; Sergent and Dehaene 2004) or else a gradable pattern for low-level tasks (e.g., "red or blue?") and a dichotomous pattern for high-level tasks (e.g., "smaller or larger than 5?") (Windey et al. 2013; cf. Windey et al. 2014). The finding of a dichotomous pattern of mean visibility ratings in high-level conditions (e.g., "smaller or larger than 5?") does not provide evidence against the hypothesis that perceptual consciousness is graded, as solving high-level tasks requires post-perceptual processing.

Attentional Blink (AB) experiments, which manipulate the allocation of cognitive resources, have yielded less consistent results. In the AB paradigm developed by Raymond et al. (1992), participants were asked to first identify the only white letter (T1) and then the letter X (T2) in a series of letters presented in rapid succession at a rate of 10 items per second (Figure 14.4). At the end of the presentation, participants were then asked to indicate whether they saw the two targets T1 and T2. T2 occurred in 50 per cent of the trials within 100–800 ms following T1 (lag 1 to lag 8). Raymond et al. (1992) found that at short T2–T1 intervals, participants who reported T1 correctly would tend to report T2 incorrectly (with the exception of the lag 1 sparing effect).

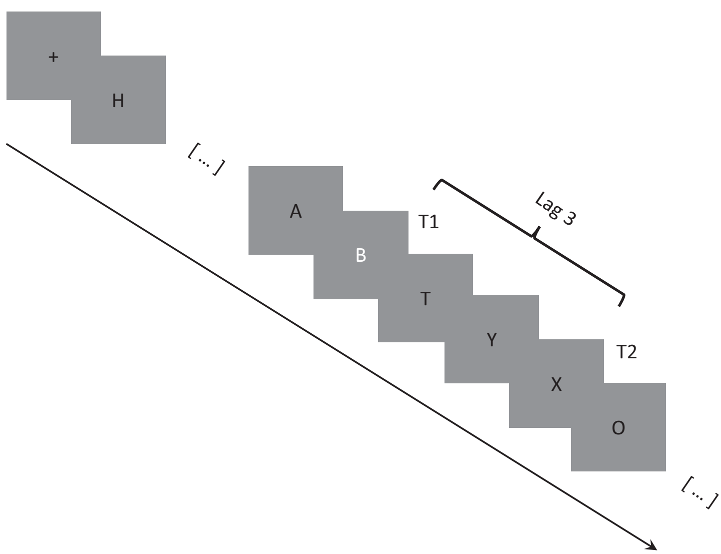

FIGURE 14.4 Illustration of the rapid serial visual presentation used in the attentional blink paradigm developed by Raymond et al. (1992). Target 1 (T1) is the white letter and target 2 (T2) is whether the letter "X" was present or not.

While the mechanism underlying attentional blink is not fully understood, the prevailing explanation, originally suggested by Raymond et al. (1992), is that attention to T1 interferes with the perception of T2. They referred to this as an "attentional blink." To rule out that the findings were due to the targets and distractors masking each other, they conducted a control experiment, where participants were only asked to identify the letter X (T2). Here, they did not observe any reporting inaccuracy, which suggests that the attentional blink was due to attention to T1 rather than masking. It might also be thought that participants reported T2 inaccurately at short T2–T1 intervals, because they failed to retain both targets in VWM until the end of the trial. However, this explanation does not align with what we know about the capacity and duration of VWM (e.g., Dall et al. 2021). One problem with Raymond et al.'s (1992) explanation of AB is that it doesn't explain lag-1 sparing—that is, the absence of AB during lag 1. An alternative explanation that does explain lag-1 sparing is that the processing of T1 locks the attentional resources, making them unavailable for T2 processing. The reason we see lag-1 sparing is that during lag 1 the processing of T1 has not yet locked the attentional resources. Once the processing of T1 has locked the attentional resources, the performance with respect to T2 deteriorates. As the attentional resources are gradually released during later lags, however, performance with respect to T2 slowly improves.

The AB paradigm has become a popular way of testing whether visual consciousness is graded. In a recent study, Eiserbeck et al. (2022) used a variation on the AB paradigm, combined with a four-scale PAS-like response-option and EEG measures. In each trial, 13 images were shown in rapid succession, each for 107 ms (Figure 14.5). The images consisted of two targets (T1, T2) and 11 distractors. T1 was a dog in half of the trials and a muffin in the others and was presented as either the third (long lag) or the seventh item (short lag). T2 was a face and was presented as the 10th stimulus in all but 3 percent of trials, where it was replaced with a distractor. Prior to each trial, participants were asked to look for either a dog or a muffin, and a face, which would not always be present. After each trial, participants indicated via a response key (a) whether they saw a dog or muffin (dog/muffin/don't know); (b) whether they saw a male or female face (male/female/don't know); and (c) how clear their subjective impression of the face was on the four-point visibility scale (1=not seen, 2=slight impression, 3=strong impression, 4=seen completely), very similar to the PAS. During each trial, EEG brainwave activity was recorded from 62 scalp sites.

The results revealed that in the short lag-T2-present trials, accuracy increased and RTs decreased in the objective gender-classification task with higher visibility ratings (Figure 14.6).

The electrophysiological recordings showed graded ERP-modulations corresponding to the different visibility ratings in the N1, N2, and P3

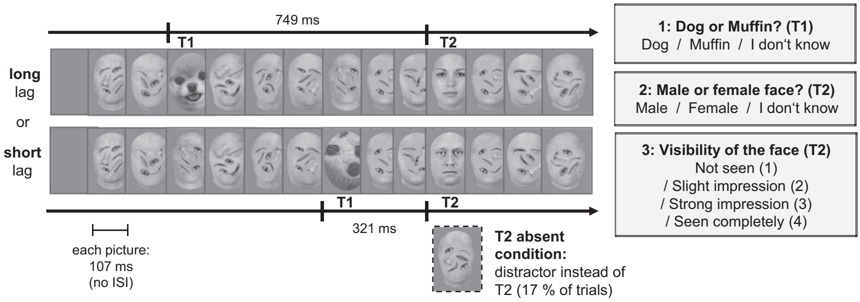

FIGURE 14.5 Structure of long- and short-lag trials. After each trial, participants answered three questions regarding T1-identity (dog/muffin/don't know), T2-gender, and T2-visibility.

Source: From Eiserbeck et al. 2022.

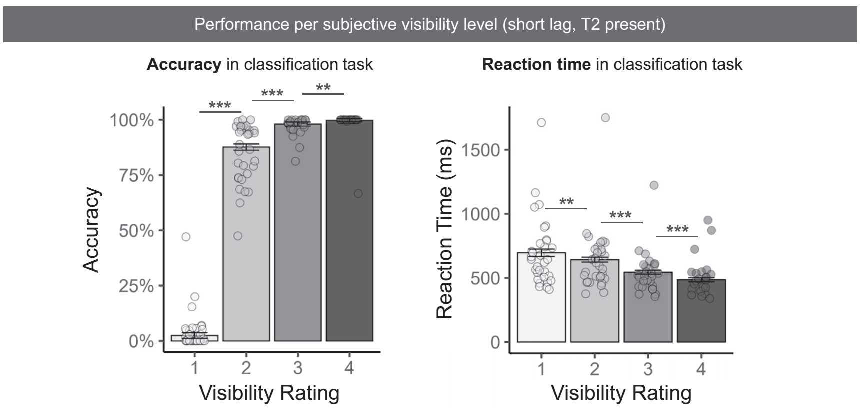

FIGURE 14.6 Accuracy and reaction time in the gender classification task as a function of visibility ratings in the short-lag-T2-present trials. The mean accuracy for "not seen" is very low, because participants were instructed to choose "I don't know" rather than 1="not seen" if uncertain about the face's gender.

Source: From Eiserbeck et al. 2022.

components, but not in the early P1 component, confirming previous findings that P1 is not a marker of visual consciousness (Figure 14.7).

In addition, Sørensen and colleagues (2014) combined a VWM resolution paradigm with Landolt rings (Wilken and Ma 2004; see Figure 14.8, and also Figure 14.9) with PAS report to investigate the relationship between P-consciousness and VWM.

The findings pointed to systematic set-size effects within the four PAS categories. That is, even though participants report the same degree or

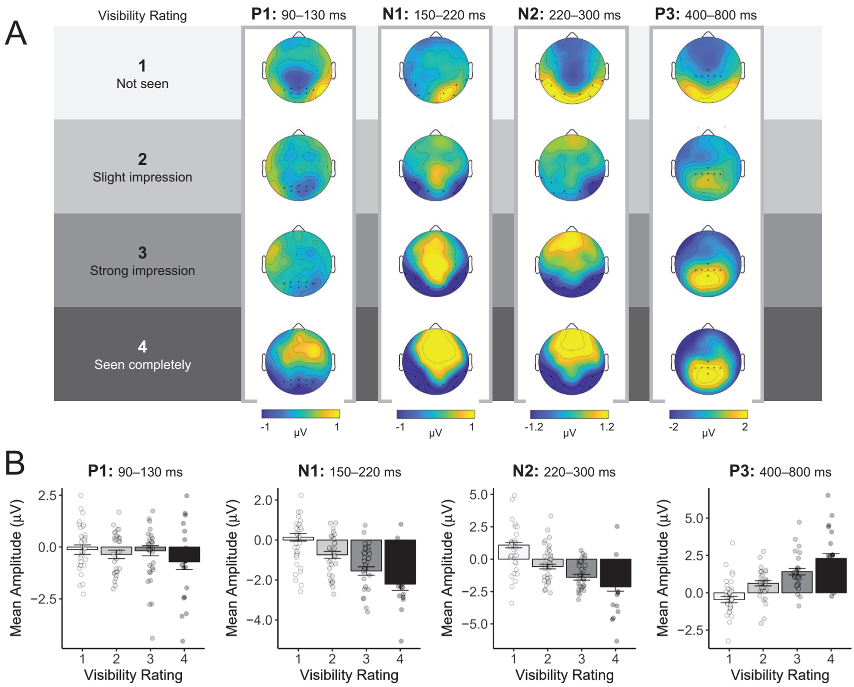

FIGURE 14.7 (a) Mean activity in P1, N1, N2, and P3 following T2-onset relative to the T2-absent condition for the different PAS-like ratings. (b) Mean wave amplitudes for P1, N1, N2, and P3 as a function of visibility ratings relative to the T2-absent condition.

Source: From Eiserbeck et al. 2022.

clearness of experience, their response performance seemed to be modulated by the set-size of the individual trial types. So, although participants report the same clarity of content, then increasing set-size of the memory array systematically increases both guessing rate and decreases the resolution of retention (Sørensen et al. 2014). Using Block's (1995) terminology, these results thus indicate that there may be varying degrees of access to the same phenomenological content, depending on the set-size of the Landolt rings presented in the experiment. Taken together, these and Eiserbeck et al.'s (2022) finding suggests that consciousness is graded.

However, a couple of older AB experiments have pointed to consciousness as dichotomous. Sergent and Dehaene (2004) conducted an AB experiment using a continuous visibility scale in single- and dual-task conditions. T1 was either "XOOX" or "OXXO," and T—which could be present or absent—was one of the French number words, "DEUX," "CINQ," "SEPT," or "HUIT." T1 and T2 were embedded among random strings of uppercase

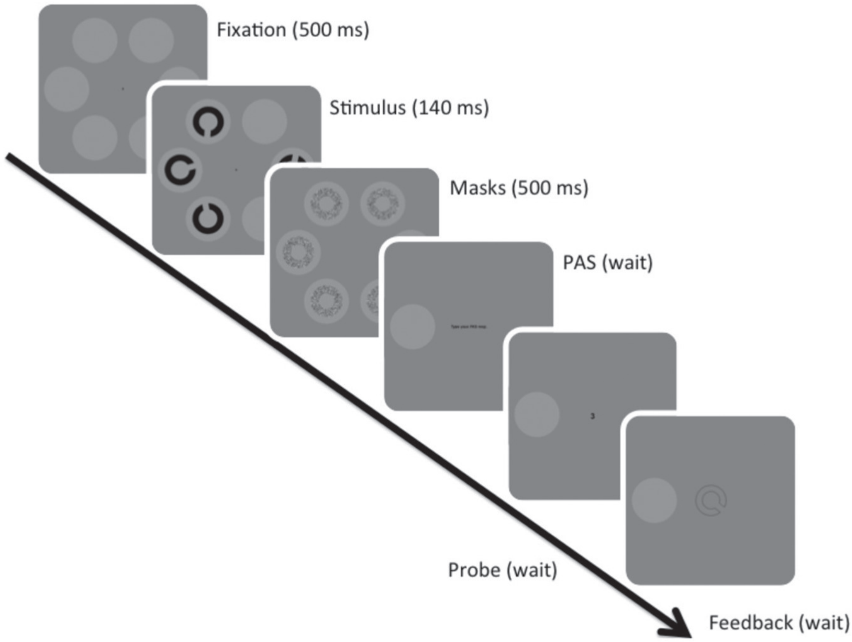

FIGURE 14.8 VWM-sets of one, two, or four Landolt rings are presented in six possible placeholders, followed by a mask on all possible positions. Then five of the six placeholders are removed, and the participants are asked to report their awareness of the target in this position using PAS. They are then presented with a wireframe probe, which they are asked to orient to match the shape of the target in this position.

Source: From Sørensen et al. 2014.

consonants generated from all consonants except Q, T, and X. In the single-task condition, native French speakers were asked to rate the visibility of T2 by moving a slider on a continuous visibility scale labelled "not seen" at the left and "maximal visibility" at the right. In the dual-task condition, participants were subsequently asked to identify the two middle letters of T1 ("OO" or "XX"). The results did not reveal any significant differences in visibility between the different lags in the single-task condition. In the dual-task condition, mean visibility ratings followed a dichotomous pattern, with statistically significant correlations between the shortest and longest lags and "maximal visibility" ratings and between attentional blink lags and "not seen" ratings. In a second AB experiment, Sergent and Dehaene manipulated the duration of T2 across different trials. Here, they found that the visibility ratings of T2 followed a dichotomous pattern within each lag of the attentional blink. Their results thus point to a notion of consciousness as dichotomous.

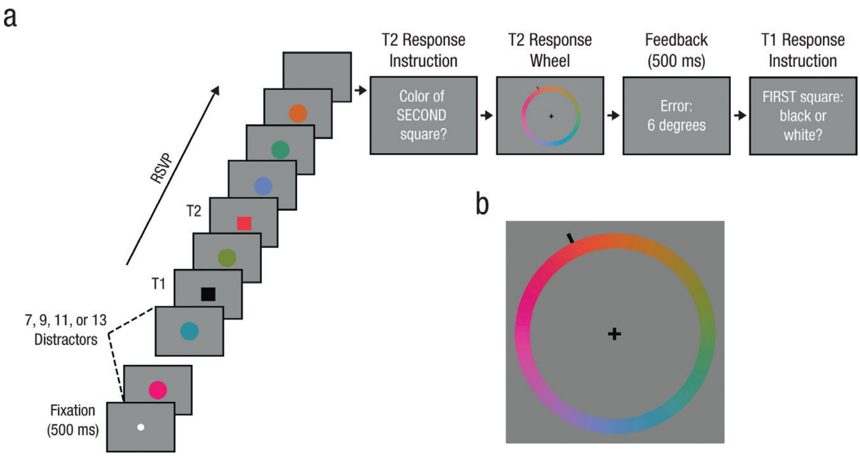

FIGURE 14.9 The colour AB task. (a) T1 and T2 were embedded in a rapid serial visual presentation stream of coloured circles. (b) Subjects first reported the colour of T2 using a colour wheel and then whether T1 was black or white.

Source: From Asplund et al. 2014.

However, these results are questionable. To rule out that participants used a dichotomous response criterion in their visibility ratings, Sergent and Dehaene conducted a backward masking study, again using the French number words, "DEUX," "CINQ," "SEPT," or "HUIT," presented at different stimulus durations across different trials. After a presentation of the mask for 300 ms, participants rated the visibility of the masked words on the continuous visibility scale. Here, mean visibility ratings were found to gradually increase with increasing stimulus durations, which they took to rule out a response bias:

> subjects reported seeing increasingly more detailed aspects of the masked stimuli—from a few features to single letters, graphemes, and finally the whole word—and they traduced this increasing detail by continuously varying the cursor on the visibility scale.
>
> (Sergent and Dehaene 2004, 727)

However, *pace* Sergent and Dehaene, these findings do not rule out a response bias. In the backward masking experiment, the masked stimuli were all T2-letter words. In the AB experiment, by contrast, a T2-letter word was only present in some trials. In T2-present trials, subjects who had only a slight impression of T2 may not have been able to tell whether T2 was a word or a distractor (e.g., "CINQ" vs. "CVNG"), which would mean that they would have responded with "not seen," as "don't know" was not a response option.

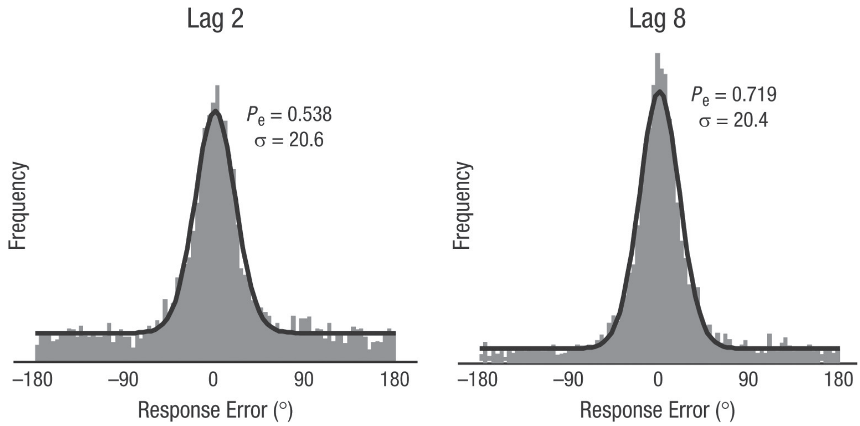

FIGURE 14.10 Distribution of response errors for T2 in the colour AB task, aggregated across all subjects separately for lags 2 and 8. P_e = probability of T2 encoding; σ = precision of T2 encoding.

Source: From Asplund et al. 2014.

Moreover, because distractors did not contain vowels or the consonants Q, T, or X, the participants may have been able to identify T2-number words like "DEUX," "CINQ," or "HUIT" from "EUX," "INQ," or "UIT" in T2-present trials, which would have led to a "seen"-rating. Yet "seen"-ratings would have been the result of a judgement about the stimulus' identity, not a perception of it. As we cannot rule out response bias, this could be a potential confound of Sergent and Dehaene's study.

In a subsequent AB experiment, Asplund et al. (2014) looked at the precision of T2-identifications at different T2-T1 lags in a colour and a face identification task. In the colour identification task, T1 was either a black or a white square, and T2 was a coloured square (Figure 14.9). Participants watched a rapid serial presentation of a black/white square (T1) and a coloured square (T2) embedded among coloured circles (distractors) at either a short lag (200ms) or a long lag (800ms) and a T2 duration of either 100 or 200 ms. Participants were then asked to identify T2 on a continuous colour wheel. Subjects received immediate feedback on response error and were then asked whether T1 was black or white. The face identification task was analogous with the T2-identification given by moving a cursor on a continuous face wheel.

The response error was given by the distance between the reported and the correct value on the continuous response wheel, and the precision of a participant's responses was given by the standard deviation of the distribution of their response errors from the correct value. The smaller the standard derivation, the greater the precision. The findings revealed the same T2 precision at shorter and longer T2-T1 lags (Figure 14.10).

Asplund et al. take this to support the hypothesis that consciousness is dichotomous, reasoning as follows. If consciousness is dichotomous, visual information is either encoded in VWM or not. So, with a longer T2-T1 lag and less attention allocated to T1, the probability that T2 is represented in VWM should increase, but the precision of T2 identifications should remain constant. Conversely, if consciousness is graded, a longer T2-T1 lag should correspond to an increase in the precision of T2-responses. As they found that the precision of T2-responses remained constant at shorter and longer T2-T1 lag, they take their findings to point to a dichotomous conception of consciousness. However, this interpretation rests on the assumption that if consciousness is graded, the increase in attentional resources with longer T2-T1 lags should lead to greater precision. But degree of precision does not by itself have any bearing on the question of whether consciousness is graded. Imprecision is just a form of inaccuracy (or non-veridicality). Yet an inaccurate perceptual representation can be subjectively indistinguishable from its veridical counterpart. So, variation in precision does not reflect a gradability of conscious accessibility or visual clarity (PAS rating) (Sørensen et al. 2014; cf. Pincham et al. 2016), but may just reflect an increase in cognitive load or attentional resources, or misleading external cues.

The available evidence thus suggests that consciousness is graded. But that presents a problem for so-called race models of perception, as these are committed to a dichotomous conception of visual consciousness.

14.3 Race/biased choice-models of perception

Perceptual information is collected via the senses and is processed by the brain. In the case of visual perception, reflected light stimulates cells in the retina, which translates the information carried by the light into a neural signal, travelling through the thalamus towards the primary visual cortex and then extrastriatal areas (V4-V5/MT). While this bottom-up process is modulated by backward projections in the visual stream, it is commonplace to think of the visual process as a linear progression from lower to higher cognitive subsystems (e.g., Gazzaniga et al. 2018). According to an influential model of perceptual processing originally advanced by Atkinson and Shiffrin (1968), external input is transferred to a sensory register and from here onto a short-term working memory store, from which inputs are selected for encoding and representation in long-term memory. Atkinson and Shiffrin (1968) even speculate that the progression of information potentials could be transferred directly from the sensory register and into long-term memory without any representation in short-term memory. The key insight of this model is that insofar as information is represented in short-term memory, this happens prior to its encoding and representation in long-term memory.

On an alternative proposal, initial attentional selection for representation in VWM partly depends on the sensory evidence that an object belongs to a certain object category, and the sensory evidence in turn is related to how well the sensory information matches template categories in long-term memory. This theoretical suggestion forms the basis of Bundesen's "A Theory of Visual Attention" (TVA), which is a model of attention that combines elements of race models of perception with elements of biased-choice models (e.g., Bundesen 1990; Bundesen et al. 2005; Bundesen and Habekost 2008). Race models of perception hold that what is represented in VWM is the result of a stochastic race between the result of matching a given visual signal to all object and feature categories stored in long-term memory. Biased-choice models of perception hold that what is represented in VWM is biased by payoff history (e.g., Luce 1963).

A combined race/biased-choice model like TVA is supported by a variety of studies demonstrating that familiarity and expertise with specific categories fundamentally affect the processing and representation of sensory information in working memory. Sørensen and Kyllingsbæk (2012) showed that as expertise with letters increased in different age groups, short-term memory capacity also increased while performance in non-trained categories (line drawings) remained stable. This pattern was later replicated in a slightly different paradigm investigating short-term memory capacity for letters, line drawings, and Japanese hiragana symbols (Dall et al. 2016). Measuring working-memory capacity in three groups of university students, Dall and colleagues (2016) demonstrated that the variation in expertise with hiragana drives how much information participants can retain in short-term memory. Both control conditions (letters and line drawings) were unaffected across the three expertise groups, as predicted. These findings have received additional support from studies demonstrating that memory capacity is higher for cartoons that are known than cartoons that are similar but not known (Xie and Zhang 2017) and higher for real flags that participants are familiar with than pseudo flags that are unfamiliar to the participants (Conci et al. 2021). In fact, the capacity of working memory seems to be driven solely by the degree of familiarity for expert participants independent of other factors, for example, simple versus complex objects. In a recent study, Dall et al. (2021) investigated how Chinese participants process Chinese characters. The stimulus was manipulated along two dimensions: physical and perceived complexity. Physical complexity was defined by the stroke count of the characters and the perceived complexity by the word frequency of the character (e.g., the character for "mountain" is more frequently used than that for "embroidery"), which enabled us to analyse high and low complexity over the four categories (viz., high perceived and high physical complexity, low perceived and high physical complexity, low perceived and low physical complexity, and high perceived and low physical complexity). Dall et al. reported that for the Chinese participants who were considered to be experts in reading Chinese, VWM capacity was driven solely by word frequency or perceived complexity, independently of stroke count. Processing speed was found to follow a similar pattern, with increased processing speed for familiar objects. By contrast, the threshold for perception was unaffected by complexity, both perceived and physical (Dall et al. 2021). These results demonstrate that expertise, or strength of category templates in long-term memory, has a significant impact on processing speed and accuracy of representation in VWM, which in turn suggests a reversal of the relationship between the role of short- and long-term memory in perceptual processing.

14.4 The template tuning theory of perception

In previous works, we have developed a model of visual perception, which we call the template tuning theory (TTT; Brogaard and Sørensen 2023, *in press a, b*). The theory was proposed as a theoretical model expanding on the basic premise that encoding relies on matching sensory information with mental templates in long-term memory (cf., Bundesen 1990). These templates can be honed with expertise to enhance categorization of objects or scenes belonging to categories that perceivers are more familiar with (e.g., Sørensen and Kyllingsbæk 2012; Dall et al. 2021). In line with Bundesen (1990), TTT posits that the perceptual mechanism can be driven by a stimulus bias (also called *filtering*) or a categorical bias (also called *pigeonholing*).[3] In the case of stimulus bias, perceptual processing is preceded by an attentional weighting of the incoming visual signals from across the entire visual field. If, say, a red dot against a green background captures your attention, then signals from the red dot are weighed higher than signals from the green background. In the case of categorical bias, perceptual processing is preceded by a strategic prioritization of a template, which increases the likelihood that a categorization is made if an incoming visual signal matches the template, as in a case where your house is burning, and you are searching for a fire extinguisher.

Assuming the visual signals from a given stimulus in the visual field are weighted higher than signals from other items in the visual field (i.e., stimulus bias), TTT stipulates that the perceptual process begins with the brain-extracting object or scene gists from the prioritized visual signals in the early visual system (Figure 14.11) (Brogaard and Sørensen 2023, *in press a; b*). Object and scene gists convey coarse-grained information about object contours, object surface patterns, global scene layout, and statistical scene regularities (e.g., printers are frequently found in offices) (Schyns and Oliva 1994; Bar 2004; Auckland et al. 2007; Oliva and Torralba 2007; Võ and Wolfe 2015; Võ et al. 2019).

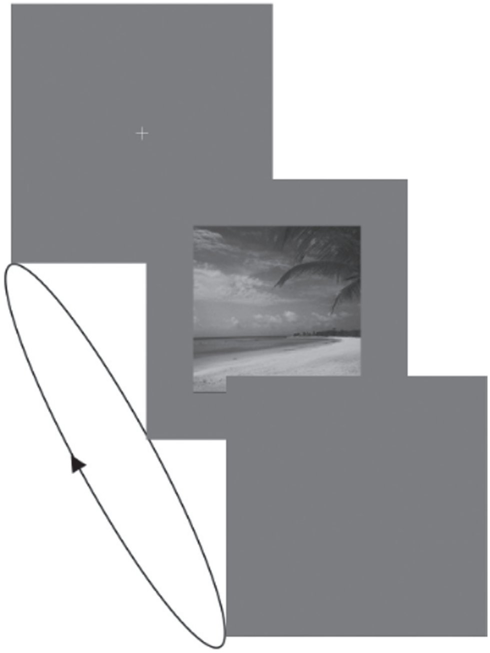

FIGURE 14.11 Gist perception at reduced speed.
Source: From KSU, Vision Cognition Laboratory.

This process occurs at a very rapid pace (Lowe et al. 2018) and once extracted, object and scene gists are rapidly projected to late stages of the visual ventral stream (e.g., Kveraga et al. 2007). Here, they activate templates in long-term memory corresponding to singleton or generic perceptual categories (e.g., the class containing a familiar person's face or the class of square objects) (Brogaard and Sørensen 2023, *in press a; b*) The visual input is also processed more slowly in a partial bottom-up fashion in the early visual ventral stream by well-defined low-level visual processes, such as double-opponent processes (cf. Bar et al. 2006; Torralba et al. 2006). After undergoing early pre-conscious perceptual processing, the partially processed visual signal is then matched with the activated object or scene templates in long-term memory until the best match has been identified (*categorization*). The categorization of the visual signal coincides with its selection for and representation in VWM, which makes the information consciously available for post-perceptual tasks (e.g., reporting, reflection, or decision-making). The diagram in Figure 14.12 illustrates the key components of TTT.[4]

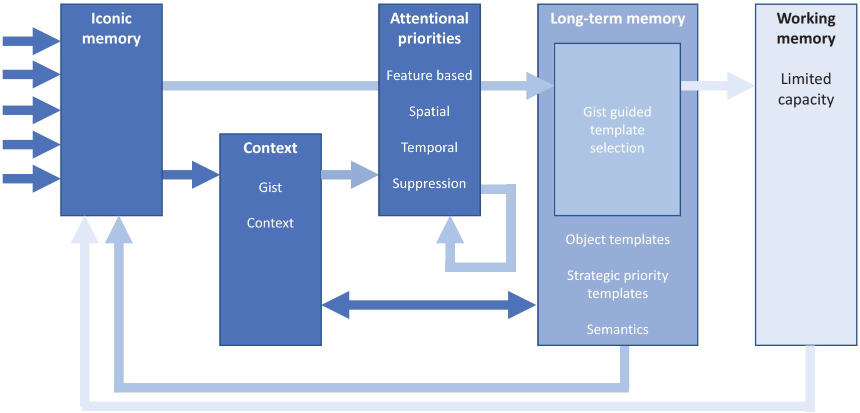

FIGURE 14.12 A diagrammatic representation of the TTT model, describing the relationship between cognitive systems and processes involved in selection and representation of active perceptual information in VWM.

Source: Created by the Authors.

14.5 Template tuning theory and graded consciousness

The attentional model that lent inspiration to TTT, as originally conceived, is committed to a dichotomous conception of visual consciousness: Once a categorization of a visual signal is made, the information is fully consciously accessible to the perceiver, which is to say that visual consciousness is dichotomous (Bundesen and Habekost 2008). Even ambiguous categorizations of a visual signal (say in the instance of bistable figures like the Necker cube, Figure 14.13) will result in representations in working memory that are fully consciously accessible to the perceiver. Of course, the representation in working memory may be re-encoded or reinterpreted (if, e.g., the perceiver experiences a shift in the surface of the Necker cube), but the re-encoded or reinterpreted representation will nonetheless still depend on a categorization of the visual signal.

If the attentional model that lent inspiration to TTT is committed to a dichotomous conception of visual consciousness, the question arises whether TTT is similarly committed. Of course, whether visual consciousness is graded is ultimately an empirical question. But as we have seen, the available evidence suggests that visual consciousness is graded to some degree (e.g., Eiserbeck et al. 2022; Overgaard and Sørensen 2004; Ramsøy and Overgaard 2004; Sørensen et al. 2014). This then gives us reason to develop a version of TTT that can accommodate these findings. It may perhaps be thought that reduced visibility and availability of perceptual information stems from a lack of suitable templates due to lack of familiarity or expertise. This proposal will not do,

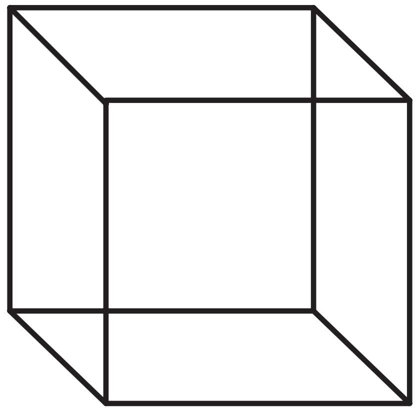

FIGURE 14.13 The Necker Cube is a bistable illusion whereby observers typically see the figure shift in which side of the cube is towards the back and which is towards the front.

Source: Created by Authors.

however, as our cognitive system can deploy multiple templates to determine the category of the object or feature. Say you see the Japanese Kanji "木" for the first time. Even if you do not have a dedicated template representation, you may be able to combine more basic shape templates for the categorization of the Japanese symbol, for instance, "Λ" and "†." Although such "makeshift" templates may slow you down on cognitive tasks, this clearly should not reduce your access to—or phenomenal awareness of—the perceptual information encoded in VWM. As our cognitive system can deploy a complex of connected templates to process new visual information, poor templates are not necessarily correlated with degraded perceptual consciousness.

However, degraded consciousness may be the result of poor template matching. One option here is that an impoverished visual signal prevents an exact match between the signal and one of the activated templates. Another possibility is that the activated templates are suboptimal due to an impoverished object gist, which might also prevent an exact match between the signal and one of the activated templates. We can refer to inexact matches between a signal and an activated template as "prediction errors" (or "categorization errors"; cf. Brogaard and Sørensen, *in press a*). If an inexact categorization is made, the perceptual information encoded in VWM will inevitably be sparser, which may result in degraded visibility and availability of perceptual information. If this suggestion is on the right track, then the size of the prediction error should be directly correlated with the degree of degradation, at least up to the point where no categorization is made. While models like TVA assume that sensory evidence is matched with all possible categories in memory, TTT makes the assumption that there is a guided template matching procedure, shaped by context, expectations, and gist. This stage pre-selects or limits the subset of potential category matches to be made.

Despite being based on race/biased-choice models of perception, which operate with a dichotomous conception of visual consciousness, a modified version of TTT can thus explain the empirical data pointing to a graded conception. To see this, consider Eiserbeck et al.'s (2022) finding that attention to T1 during short T2–T1 lags attenuates the visibility and availability of T2 information. TTT can explain this finding either in terms of reduced signal quality (hereby increasing the prediction error) or reduced gist quality (widening the subset of potential categories, and thus also increasing the prediction error). Attenuated attention to T2 during AB might have impaired the quality of the visual signal, thus making it less likely that the signal will exactly match one of the activated templates. Alternatively, diminished attention to T2 during AB might have impaired the quality of the gist information, which would also reduce the likelihood that the signal would exactly match one of the activated templates.

These alternatives are, of course, not mutually exclusive. But whereas an inexact match due to an impoverished signal may explain graded consciousness in masking/low contrast experiments, an inexact match due to an impoverished T2 gist may at least partly explain the findings in AB experiments. Indeed, Eiserbeck et al. (2022) found graded ERP-modulations corresponding to the different visibility ratings in the N1, N2, and P3 components. P3 may reflect VWM encoding and post-perceptual VWM tasks, but N1 and N2 are widely regarded as indicators of perceptual processing prior to encoding in VWM. The graded pattern found in the N1 component may reflect disruptions in early perceptual processing as a result of attenuated attention to T2 during the short T2-T1 lags. Diminished attentional engagement with T2 may have interfered with the extraction of T2-gist information, leading to an impoverished T2 gist and the activation of face templates lacking some, though not all, gender cues. This, in turn, would explain why accuracy decreased and RTs increased in the gender-identification task with lower visibility ratings in the short lag-T2-present trials.

While TTT in principle is compatible with both a graded and a dichotomous conception of consciousness, the empirical evidence presented above seems to favour the former.

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Notes

1 Something similar can occur as a result of eye lens abnormalities, which can reduce the acuity of the visual signal with respect to spatial features (e.g., form) of stimuli that are far away (myopia, or nearsightedness) or close up (hyperopia or farsightedness).

2 Different types of attention might affect access in different ways. For instance, if an array of stimuli (or a natural scene) is globally and diffusely attended, there may be decreased access to information about the elements making up the array; cf. Lopez (2020).

3 "Or" is here to be read as the inclusive "or." We leave open the question of whether perceptual processing always involves both stimulus bias and categorical bias.

4 The term "iconic memory" originates in Sperling (1960), who found evidence of the existence of a transient, yet high-capacity, visual memory store. In one condition, participants were briefly presented (50 ms) with an array of consonants (3 rows and 4 columns) and asked to report as many consonants as possible. In this condition, Sperling found that the participants were able to report an average of 4.4 consonants. In a second condition, an individual row was cued immediately after the presentation of the consonants. In this condition, participants were able to report 3.3 consonants in the cued row. Sperling took this to suggest that participants were storing nearly all the consonants in a way that allowed them to attend to the cued row and encode the cued consonants in VWM after the presentation. When the cue was delayed 1s, however, the volunteers were only able to recall an average of 1.5 consonants from the cued row, suggesting that the iconic memory representation of the visual array had decayed. Block (1995) has interpreted these findings as evidence of P-consciousness in the absence of A-consciousness. However, another explanation is that in the first condition only the scene (i.e., the array of the 12 consonants) was represented in VWM as a single diffusely attended item, whereas in the second condition the cue was able to cue a specific row in the scene gist, allowing for three of the consonants in the row to become represented in VWM as three distinct items.

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