3

BLINDSIGHT IS UNCONSCIOUS PERCEPTION

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3.1 Introduction

In humans, perception of visual information is mediated by a pathway from the retina to the primary visual cortex (V1, striate cortex) via the lateral geniculate nucleus (LGN). From V1, the visual information is further processed in extrastriate cortical areas in two visual pathways—the ventral visual stream, which runs through the temporal cortex and mediates object perception, and the dorsal visual stream, which runs through the parietal cortex and mediates visually guided behaviours (Goodale and Milner 1992). V1 lesions therefore result in a disruption of the processing of visual information, which gives rise to a blind spot or scotoma in the visual field (Cowey, 2010). Despite that, residual visual abilities have been found in the scotoma of individuals with lesions to striate cortex in the occipital lobe without any reported visual awareness (see, e.g., Weiskrantz 1986; Zeki and ffytche 1998). This is the phenomenon known as 'blindsight'.

The question of whether blindsight is a form of unconscious perception continues to spark fierce debate in philosophy and psychology (see, e.g., Morland et al. 1999; Overgaard et al. 2008; Brogaard 2011a, 2011b; Peters and Lau 2015; Peters et al. 2016, 2017; Berger and Mylopoulos 2019; Phillips 2021; Michel and Lau 2021; Skrzypulec 2022; Michel 2023). Unlike pure sensory processing, perception is the result of a categorization of a sensory signal. In neurologically healthy subjects, the categorization of a sensory signal coincides with the encoding and representation of the categorized information in visual working memory. The encoding and representation of this information in visual working memory make the information directly available for decision-making and verbal report, and correlates with the visual

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clarity of what is represented (Ramsøy and Overgaard 2004). In blindsight, the encoded information is not directly available to the subject for decision-making and verbal report but can be accessed in forced-choice experimental procedures, where blindsight subjects are asked to guess whether a stimulus or stimulus feature is presented to them in their blind field.

One side of the debate holds that while the visual information categorized in blindsight is not access-conscious (in Ned Block's 1995 sense), it is nonetheless a form of perception, albeit a form of unconscious perception that does not afford direct access to the categorized information (Brogaard 2011a; b; Michel and Lau 2021; Michel 2023). The opposition, by contrast, holds that blindsight is just a form of degraded conscious perception that makes the categorized information harder to access because it is degraded (Overgaard et al. 2008; Phillips 2021; Skrzypulec 2022).

One line of argument for the thesis that blindsight is a form of degraded conscious vision is that the findings in blindsight studies are due to a response bias in the procedures used for measuring awareness (Overgaard et al. 2008; Phillips 2021). Traditional blindsight studies use signal detection procedures that ask subjects whether a stimulus or stimulus feature is present, followed by a question about the subjects' confidence in their subjective report. It has been argued that these procedures may not be sufficiently sensitive for gathering subjective reports of awareness (Morland et al. 1999; Stoerig and Barth 2001; Ro et al. 2007; Phillips 2021). This problem is exacerbated because blindsight is degraded and qualitatively different from normal sight, which makes it difficult for blindsight subjects to recognize their detection of a stimulus as a kind of conscious vision.

A related argument for the thesis that blindsight is a form of degraded conscious vision is that the findings in blindsight studies are skewed because a binary rather than multiple-point scale is used to measure perceptual awareness (Overgaard et al. 2008; Phillips 2021). When an appropriate scale is used to measure perceptual awareness, it is argued, blindsight is not really 'blind', but is a form of degraded conscious vision that correlates with the accuracy of the subjective reports.

Here, we address the opposition's arguments for thinking that blindsight is degraded conscious vision. After providing an overview of the signal detection procedures traditionally used in blindsight studies, we argue that these procedures already have the resources for ruling out that evidence of blindsight can be attributed to a response bias. We then vet the empirical evidence for thinking that blindsight is a kind of degraded conscious vision and show that the awareness detected with alternative procedures is a form of non-perceptual awareness. To back this claim, we examine the residual visual abilities to detect and discriminate colour found in some blindsight patients and argue that residual consciousness in blindsight is indirect and lacks the phenomenal character characteristic of conscious vision.

3.2 Signal detection theory and psychometric procedures

One line of argument for the thesis that blindsight is a form of degraded conscious vision is that the findings in blindsight studies are due to a response bias in the procedures used for measuring awareness (Overgaard et al. 2008; Phillips 2021). In what follows, we provide a brief description of the theoretical framework governing the experimental methods and argue that these arguments are unsuccessful.

Signal detection theory (SDT) is a dominant theoretical framework and mathematical tool for understanding how subjects make detection and discrimination decisions (Green and Swets 1966; Macmillan and Creelman 2005). SDT provides a precise way of analyzing decision-making under uncertainty resulting from noise (e.g., variable neural responses to a stimulus). There are two main components to the decision-making process: the signal strength and the criterion. The 'signal strength' refers to the magnitude of the internal response to the signal strength (*d'*) of a stimulus after we account for noise. For example, if the signal is noisy (say, too dim for the subject's visual system to register), the subject's performance will be negatively affected. The 'criterion' (also known as the 'response criterion' or 'criterion bias') refers to the standard a subject uses to make detection and discrimination decisions. For example, if subjects have a tendency (bias) to select a certain stimulus feature independently of their sensitivity to it, then their response will be biased. Because there are two components to the decision-making process, two measurements are taken—one for the signal strength and a separate one for the response criterion.

Each of these components (the signal strength or the criterion) may affect the subject's performance. The four most common psychometric procedures used in detection and discrimination tasks are Yes/No, Forced-Choice, Two-Alternative Forced-Choice (2AFC), and Two-Interval Forced-Choice (2IFC).

In Yes/No procedures, a target stimulus is presented in some trials but not in others. On each trial, subjects are asked to report whether or not they saw the target stimulus by responding "Yes"/"Seen" or "No"/"Unseen". The percentages of "Yes"/"Seen" responses out of all responses (which represent the probability of detection) for each trial is calculated using psychometric functions. One such function can be visually represented as a curve that plots the probability of the subject responding "Yes" at a certain threshold as a function of the signal strength (Figure 3.1).

The Yes/No procedure has notable limitations. Because it only allows for Yes/No responses, the estimates that can be made are limited to hits (i.e., the target stimulus is present and the subject responds "Yes") or misses (i.e., the target stimulus is present and the subject responds "No"). Consequently, the data cannot be used to estimate the internal response to the signal strength (*d'*) separately from the subject's response criterion (Figure 3.2).

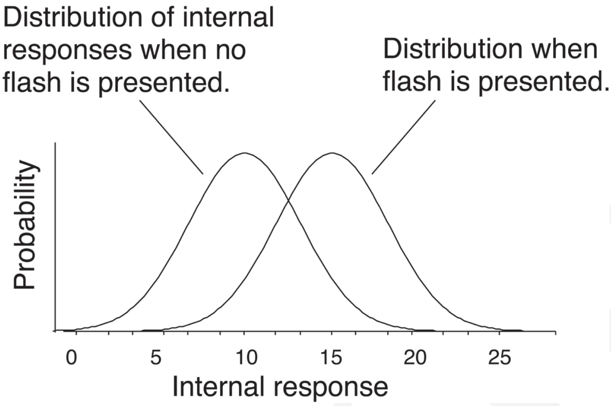

FIGURE 3.1 A toy illustration of internal response probability of occurrence curves for noise-alone (no stimulus is present) and signal-plus-noise (stimulus is present) trials.

Source: From David Heeger with permission.

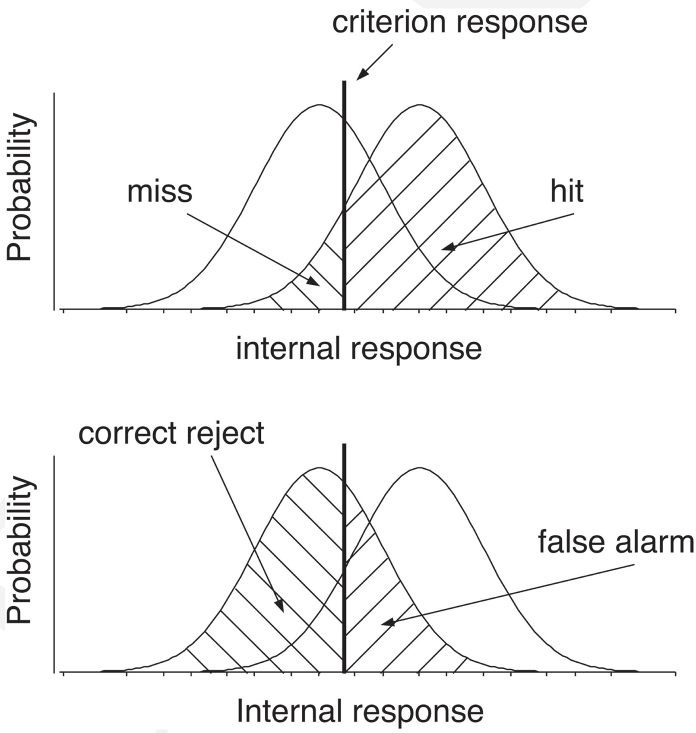

FIGURE 3.2 A toy illustration of internal response probability of occurrence curves for miss/hit (above) and correct reject/false alarm (below).

Source: From David Heeger with permission.

What does that mean for blindsight studies? Yes/No procedures cannot be used to estimate whether blindsight subjects report not seeing the stimulus because either there is no internal response to the signal strength (*d'*) or a criterion that biases their responses is used. This problem arises because all of the trials in Yes/No procedures are stimulus trials—that is, there are no blank or noise-alone trials (catch trials). Since we get only hits and misses, we cannot estimate false alarms (i.e., the target stimulus is absent, and the subject responds "Yes"). But, according to SDT, in order to determine the internal responses of blindsight subjects, we need to know both the hit rate and the false alarm rate. Phillips (2021), for example, argues that some early studies of subliminal perception that claimed to find a dissociation between performance and awareness (e.g., Sidis 1898; Williams 1938) were later discounted because the stimuli presented were either too dim or too distant (Eriksen 1960). Phillips uses this case to argue that the dissociation between performance and awareness found in blindsight studies does not provide evidence for unconscious perception. At best, he claims, it provides evidence for degraded conscious perception that arises because the signal strength is below the threshold that would allow it to produce a strong internal response, thereby negatively affecting performance. In other words, subjects see the target stimulus but because, say, it is too dim or has low contrast, it is represented as faded or unclear. But if the criterion the subjects use to judge whether they see the stimulus or not is based on the prominence or clarity of the stimulus, the resulting dissociation between performance and awareness will not be evidence of unconscious perception. At most, it will be evidence of degraded awareness. Suppose, for example, that the criterion blindsight subjects use for responding "Yes" ("I see the stimulus") is that the stimulus is as prominent or clear in their blind field as it is in their normal field. This criterion will then skew their responses, as they would respond "No" ("I do not see the stimulus") even when they do see the stimulus in their blind field, albeit not as prominently or clearly as they see it in their normal field. However, Phillips's argument doesn't work for any of the other procedures since they can control for criterion bias.

In forced-choice procedures, a target stimulus is presented at the minimal detectable or discriminable level of stimulation (absolute threshold) in some trials but not in others (catch trials). Subjects are forced to respond to every trial either by hitting a "Yes"/"Seen" button or a "No"/"Unseen" button and are required to guess when unsure. There are four possible measurements in forced-choice procedures. The target stimulus is present and the subject responds "Yes" (hit); the target stimulus is present and subject responds "No" (miss), the target stimulus is absent and the subject responds "Yes" (false alarm), the target stimulus is absent and subject responds "No" (correct rejection). Hits and correct rejections reflect good performance while misses and false alarms do not. According to SDT, in order to determine the internal responses to the signal strength of blindsight subjects, we need to know both the hit rate and the false alarm rate. Unlike Yes/No procedures, forced-choice procedures can be used to evaluate both the number of correct answers and the number of false alarms in order to get an estimate of the signal strength (*d'*). They can thus control for criterion bias.

2AFC and 2IFC procedures are used most frequently in blindsight studies (Azzopardi and Cowey, 1998). In 2AFC procedures, subjects are presented with a series of trials in which a target stimulus (e.g., a blue patch) is presented in a given location (e.g., on the right of the screen), and subjects are asked to choose between two alternatives (e.g., 'left' or 'right'). 2IFC procedures consist of a series of trials comprising two intervals (i.e., sub-trials), which are presented sequentially (Peters and Lau 2015). The target stimulus (plus noise, e.g., 'masked' stimulus) is randomly presented either in the first or the second interval, with the other interval being a blank (i.e., no stimulus or noise-alone). Subjects are asked to report in which interval the stimulus was presented, that is, "first" or "second". In 2AFC and 2IFC experiments, the task is not merely to detect a stimulus since there is always a stimulus, but rather to indicate in which of two alternative screen locations or intervals the target stimulus occurred.

Forced-choice, 2AFC, and 2IFC procedures are preferable to Yes/No procedures because they can estimate the signal strength separately from the criterion. In other words, the estimate of the signal strength does not depend

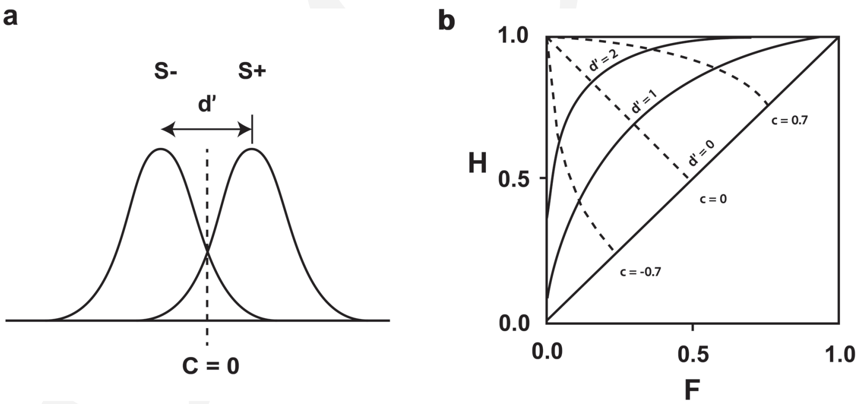

FIGURE 3.3 Signal detection. (a) The ROC curve represents a subject's internal response (*d'*) in relation to the absence of the target (S-) and the presence of the target (S+); when the number of hits (H) equals the number of false alarms (F), d'=0. Detection tasks involve setting a response criterion bias (*c*) below which a subject *S* would respond "S-" and above which *S* would respond "S+". (b) The ROC curve represents the theoretical relation between internal response and criterion bias.

Source: From Azzopardi and Cowey 1998.

upon the criterion the subject is utilizing, and as such it is a true measure of the internal response resulting from the target stimulus. This is indeed their primary virtue, and the reason that they are more widely used than Yes/No procedures. Measuring the internal response to the signal strength (*d'*) requires measuring both the hit rate (H) and the false alarm (F) rate. We can then read off the signal strength (*d'*) from a Receiver Operating Characteristic (ROC) curve, which is a graph depicting sensitivity as the discrimination threshold is varied (Figure 3.3a).[1] For example, when the noise is greater, the curve is wider, and there is more overlap. When the signal strength is stronger, the internal response increases, and the magnitude of *d'* increases (e.g., as shown in Figure 3.3b, when *d'* = 2, the ROC curve bows out more).

Peters and Lau (2015) conducted a 2IFC study on neurologically healthy subjects using two intervals consisting of a Gabor patch (of grey and white stripes) tilted either to the right or to the left (see Figure 3.4a). Gabor patches are the sort of stimuli that drive early visual activity in a controlled fashion. Each trial consisted of two sequential intervals in which the target patch

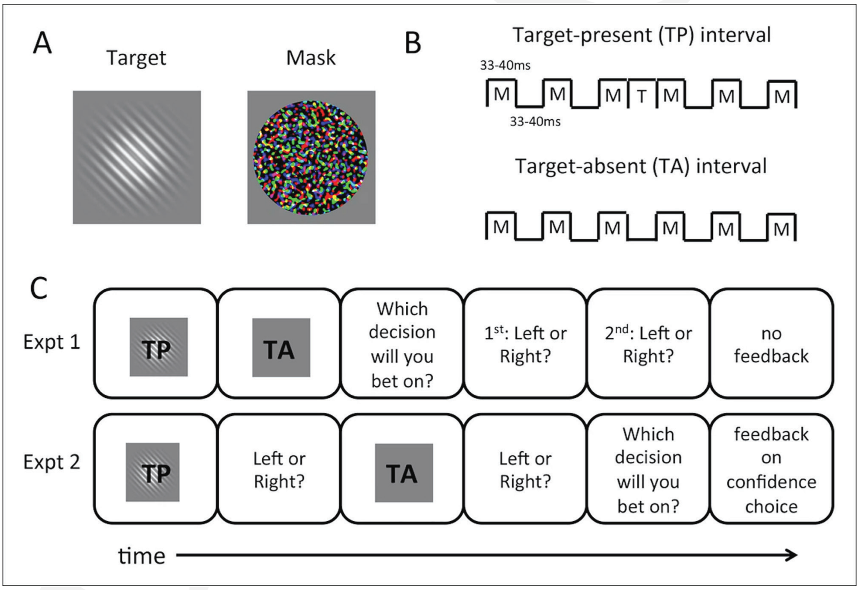

FIGURE 3.4 2IFC task. (a) Targets are either right-tilted or left-tilted gratings and masked. (b) Some intervals contained a target (TP) while in others the target was replaced by a blank frame (TA). (c) In Experiment 1 subjects betted on which discrimination decision they felt more confident in and then stated the orientation of the gratings in both intervals. In Experiment 2, subjects betted on the interval after the discriminations followed by feedback.

Source: From Peters and Lau 2015.

(T) was forward- and backward-masked (shown as 'M' in Figure 3.4b) to prevent subjects from consciously registering it. Gabor patch targets were presented only in target-present (TP) intervals. In target-absent (TA) intervals, the target was replaced with a blank frame (catch trials). Subjects were asked to report which of the two discrimination decisions they felt more confident in (right-tilted or left-tilted interval) by betting on their discrimination decision in either the first or second interval (Figure 3.4c, see Expt 1). The results revealed that the subjects correctly identified the target's orientation more than 50 percent of the time. So, the performance was non-random. But they bet on the target-present interval 50 percent of the time. So, the betting was random. Peters and Lau (2015) claim that these results at first may seem to indicate a dissociation between performance and awareness. However, a Bayesian analysis indicated that even an ideal subject is expected to show this level of dissociation. On the basis of this comparison, they argue that the results do not indicate a significant level of dissociation between performance and awareness.

The results in such experiments are sometimes taken to demonstrate that blindsight is not unconscious perception but is, at best, degraded conscious perception (Phillips 2021). However, this doesn't follow. At most, these findings show that it is difficult to elicit blindsight in neurologically healthy subjects (Azzopardi and Cowey 1998). In fact, as Peters and Lau (2015) note, such 2IFC procedures can provide a straightforward interpretation of the confidence-ratings of blindsight patients: if performance without awareness occurs, we would expect subjects to correctly identify the target's orientation more than 50 percent of the time (i.e., above-chance performance) yet bet on the target-present interval 50 percent of the time (i.e., random bets). Such betting behaviour would indicate that a specific above-chance discrimination seems introspectively no different to a blindsight subject than a random guess based on a blank, which would in turn indicate that the discrimination is unconscious.

Azzopardi and Cowey (1998) conducted a 2AFC study on a blindsight patient, GY, who provided evidence of unconscious perception. GY reported no awareness of transient stimuli presented in his blind field even though he was able to detect and discriminate them. The study consisted of three experiments, all of which required GY to simply detect the presence or absence of (distinct) target visual stimuli presented in his blind field (Figure 3.5).

The first experiment aimed to identify whether GY's response criterion varied consistently between Yes/No and 2AFC tests. It comprised Yes/No, forced-choice, and 2AFC tasks. A crucial difference between Yes/No and forced-choice tasks, on the one hand, and 2AFC tasks, on the other, is that the latter are designed to account for criterion bias. In Yes/No and forced-choice tasks, by contrast, subjects are free to vary (whether intentionally or not) their response criterion from trial to trial. In the current experiment,

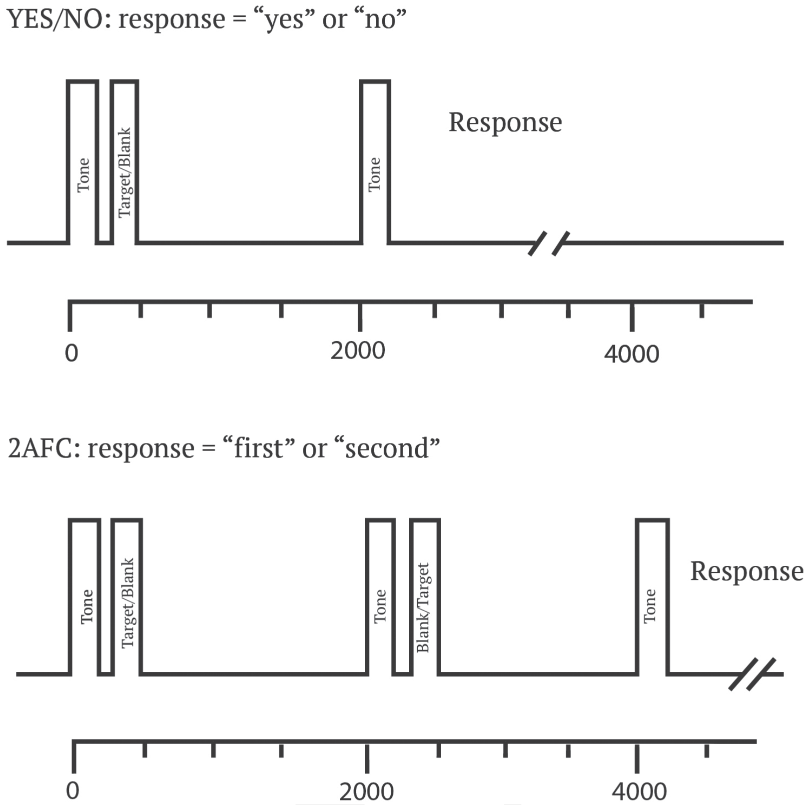

FIGURE 3.5 Implementation and timing for the Yes/No and 2AFC tasks.
Source: From Azzopardi and Cowey 1998.

the Yes/No and forced-choice tasks consisted of trials in which the target (a white disc) was either present or not, and GY had to report "Yes" if he saw something, or "No" if he did not (Yes/No), and guess otherwise. The forced-choice task was included to minimize guessing in the Yes/No task without explicitly instructing GY how to respond. The 2AFC task comprised trials in which the target (a white disc) was presented in the first or second of the two temporal intervals. GY was instructed to report whether the target was present in the first or the second interval. The results indicated that responses varied systematically between the Yes/No and forced-choice tasks, on the one hand, and the 2AFC task, on the other. Specifically, GY's reports revealed a criterion bias in the Yes/No and forced-choice tasks. However, GY's reports did not reveal a criterion bias in the 2AFC task. Recall that one of the worries raised about the findings in blindsight studies was that a response criterion could be skewing the reports of blindsight subjects (Phillips 2021). However, this worry arises only when the responses are not measured independently of the response criterion as is the case in Yes/No and forced-choice tasks. But when the reports are measured independently of a response criterion as in the case of 2AFC tasks, these worries are unfounded.

The second experiment aimed to determine GY's sensitivity to *static* target stimuli. Here, the tasks were identical to the Yes/No and 2AFC tasks used in the first experiment (but no forced-choice task was used). The target stimuli were static, vertical, black-and-white square-wave gratings against a background at four contrast values (viz., 0.65, 0.75, 0.85, and 0.95). In the Yes/No task, the target was either present or not, and GY was instructed to report "Yes" if he saw something or "No" if he did not. The 2AFC task comprised trials in which the target (at a given contrast) was presented in one of the two temporal intervals. In this task, GY was instructed to report whether the target was presented in the first or the second interval. The results indicated that, at all four contrasts tested, GY was significantly more sensitive to the stimuli in the 2AFC task than in the Yes/No task compared to controls.

The third experiment aimed to determine GY's sensitivity to *moving* target stimuli. Again, Yes/No and 2AFC tasks were used. Here, the stimuli used consisted of moving bars and moving random clusters of dots. The bars were moving past a square window and remained present for as long as it took for them to travel from one edge of the square to the other. The random clusters of dots (whose patterns were changed discretely between trials) moved behind a circular window for 1000ms but always remained visible while stationary. In the Yes/No task, the target (e.g., the moving bars or the moving clusters of dots) was either present or not, and GY was instructed to report "Yes" if he saw something or "No" if he did not. The 2AFC task comprised trials in which the target was presented in one of the two temporal intervals, and GY was instructed to report whether the target was presented in the first or the second interval. The results indicated that GY's sensitivity did not differ significantly between the Yes/No and 2afc tasks.

To recap: SDT provides a model of detection and discrimination performance by virtue of the relationship between stimulus strength (sensitivity) and response criterion. However, since SDT is not in the business of explaining either of these variables, decisions about stimulus strength or response criterion are left to the experimenters. This has led some to argue that experiments based on the SDT framework do not provide evidence of unconscious perception in blindsight (Phillips 2021). However, as we have shown, this argument is problematic because controlling for criterion bias is inherent in the 2IFC design (Azzopardi and Cowey 1998). Moreover, the results in the 2AFC task in the first experiment (discussed above) indicated a clear dissociation between GY's visual performance and visual awareness. Since these results cannot be discounted on the basis of GY's performance being skewed by the criterion bias, they support the claim that blindsight involves unconscious perception.

3.3 Is colour blindsight graded conscious perception?

Another argument against the thesis that blindsight is unconscious perception turns on the finding that when a four-point awareness scale is used to measure visual awareness, blindsight subjects report residual awareness more often than when traditional binary measures (e.g., Yes/No, forced-choice, 2AFC, and 2IFC tasks) are used (Overgaard et al. 2008). Moreover, the residual awareness in blindsight seems to correlate with accuracy, suggesting that blindsight is in fact a form of conscious perception, albeit a degraded form (Overgaard et al. 2008; cf. Phillips 2021; Skrzypulec 2022).

A four-point Perceptual Awareness Scale (PAS) was originally developed by Ramsøy and Overgaard (2004) as a measure of visual awareness in neurologically healthy participants. When presenting shape stimuli at different contrasts to healthy participants, Ramsøy and Overgaard (2004) found that most of them spontaneously evaluated the stimuli in terms of their visual clarity on a four-point scale: (CI) clear image, (ACI) almost clear image (WG) weak glimpse, and (NS) not seen. The reported visual clarity of the stimuli was found to correlate with reaction time/accuracy (Ramsøy and Overgaard 2004).

Using the PAS scale, Overgaard et al. (2008) examined blindsight subject GR, who had sustained lesions to the left part of her visual cortex. The first experiment aimed at determining the extent of GR's visual deficits. GR was presented with a flashed letter in one of 50 regions of her visual field and was then asked to indicate whether she had detected anything (Figure 3.6). GR missed all presentations in the upper right quadrant (Figure 3.5), which was consistent with the extent of her V1 lesions.

In the second and third experiments, a letter was flashed in either GR's healthy or blind field, and she was asked to assess the presentation using a binary measure (experiment 2) or the PAS-scale (experiment 3). When using the PAS scale, GR did not report nearly as many stimuli as being fully clear (CI) in her blind field as she did in her intact field, but accuracy and response time were found to correlate with reported visual clarity of the stimulus in both her blind and intact fields. When comparing trials using the binary measure to trials using the PAS scale, GR's threshold for reporting awareness was found to be lower with the PAS scale compared to the binary measure (Table 3.1).

The correlation between degree of reported visual awareness and accuracy, Overgaard et al. (2008) argue, indicate that GR's spared visual performance is not a form of unconscious perception but rather a form of conscious perception. They conclude that these findings call many of the traditional studies purporting to demonstrate unconscious perception in blindsight or normal subjects into question, as the use of a binary measure may have resulted in subjects classifying degraded conscious perception as unconscious.

Although Overgaard et al. (2008) have not shown that similar studies conducted with other blindsight subjects will demonstrate similar correlations

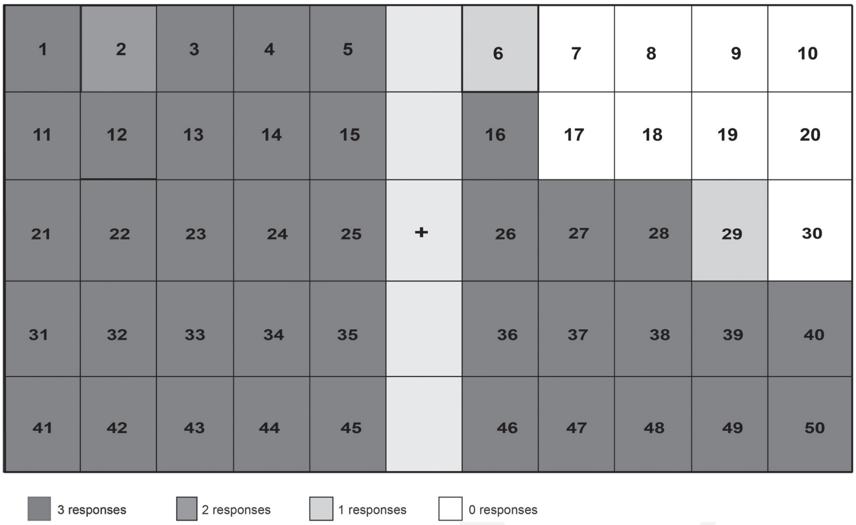

FIGURE 3.6 GR was asked to indicate whether she had detected anything after being presented with a flashed letter in one of 50 regions of her visual field. The responses were as follows: 3 responses for numbers shown in the dark grey background; 2 responses for number 2; 1 response for numbers 6 and 29; and no responses for numbers shown in the white background.

Source: From Overgaard et al. 2008.

TABLE 3.1 GY was presented with a stimulus and asked to rate it on a binary measure of visual awareness (forced-choice) or the PAS scale

	Intact field		*Injured field*	
	Correct	*Incorrect*	*Correct*	*Incorrect*
Seen	27	0	6	1
Not seen	2	4	12	14
	Intact field		*Injured field*	
	Correct	*Incorrect*	*Correct*	*Incorrect*
CI	21	0	7	0
ACI	8	1	8	3
WG	1	2	3	9
NS	0	0	0	3
	Intact field		*Injured field*	
	Correct	*Incorrect*	*Correct*	*Incorrect*
CI-ACI	29	1	15	3
WG-NS	1	2	3	12

Source: From Overgaard et al. (2008).

between residual visual abilities and PAS-ratings, there is indeed some reason to think that something similar might be found in other blindsight patients as well. As early as 1917, army physician George Riddoch reported having found motion awareness in the scotomatous fields in soldiers with lesions to striate cortex but with no abilities to characterize other attributes of the visual stimuli. Riddoch's patients would report seeing the motion of objects but would claim that these objects had no distinct shape or colour, or that they had an appearance that the patients would describe as "shadowy grey" or "like a shadow". One patient reported being able to determine the colour of the stimulus when the stimulus was white and another denied seeing motion but reported that he knew when something had moved through his hemianopic field (Riddoch 1917). Blindsight in individuals with residual awareness of the presence and direction of fast-moving and/or high-contrast visual stimuli is also known as 'type-2 blindsight' (Weiskrantz 1986; Zeki and ffytche 1998; Brogaard 2015). Residual visual awareness in blindsight was already reported when the first systematic studies of blindsight were published by Larry Weiskrantz and others (e.g., Weiskrantz 1986; Stoerig and Cowey, 1989). However, researchers originally sought out experimental conditions that would eliminate the residual awareness. It was found that eliminating the residual awareness sometimes resulted in an improvement in performance (Weiskrantz 1986). Since the first reported cases of the condition, there have been numerous studies of residual awareness in individuals with blindsight, including the widely studied blindsight subject GY, who originally described his residual awareness of motion in his blind field as a visual experience of a shadow. He subsequently described it as a feeling of something happening or a feeling of certainty that something had happened and maintained that his earlier description was a metaphor (Zeki and ffytche 1998; ffytche and Zeki 2011). He later characterized his spared visual awareness as "a black shadow moving on a black background", maintaining that this was the best he could do by way of verbally articulating his residual visual awareness in a meaningful way.

It is thus widely agreed that residual awareness of the presence and direction of fast moving and/or high-contrast visual stimuli occurs in individuals with blindsight. As Overgaard et al.'s (2008) study paradigm involved flashing a letter onto a computer screen, it is thus to be expected that GR would be aware of the presence of a stimulus on the basis of a 'feeling' of something moving. But this finding does not show that blindsight is never a form of unconscious perception. To see this, it will be helpful to look closer at GY's reliance on 'feelings' to detect and discriminate colour stimuli in his scotoma (Stoerig and Cowey 1989, 1991, 1992; Cowey and Stoerig 1993; Brent et al. 1994; Boyer et al. 2005; Alexander and Cowey 2010). Alexander and Cowey (2010) conducted a study of colour discrimination and detection in blindsight. In the first experiment, GY was presented with a luminance

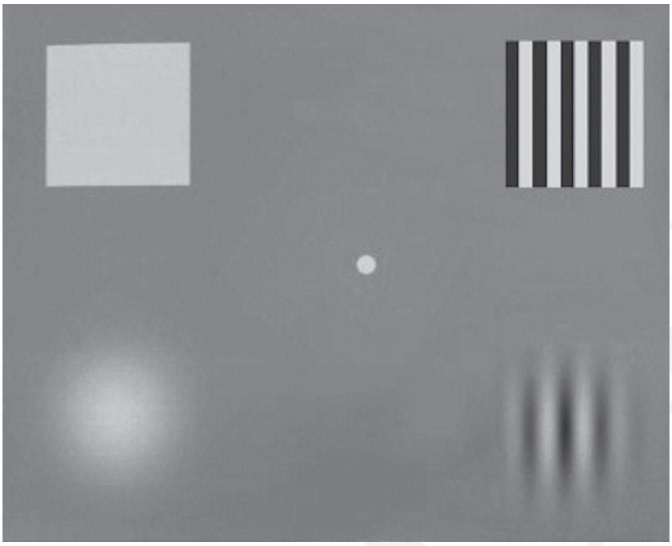

FIGURE 3.7 Examples of stimuli in the localization paradigm. Top: plain square, square-wave grating. Bottom: Gaussian patch, Gabor patch.

Source: From Alexander and Cowey 2010.

stimulus for 200ms in one of the four quadrants of the display. The stimuli were a white square, a vertical square-wave grating, a Gaussian patch (with fuzzy edges) with the same mean and peak luminance, a Gaussian patch with the same mean but higher peak luminance than the square, and a Gabor of the same mean luminance and contrast as the grating (Figure 3.7). The results revealed that GY was much slower to react to the Gabor and grated stimuli, which lacked sharp luminance contours, than to the square and the Gaussian patches, which had sharp luminance contours.

In the second experiment, GY was presented with a Gaussian blob (with blurred boundaries) with sharp temporal onsets and offsets (Figure 3.8).

GY was able to tell whether the blob had changed in colour at every frequency of red/green luminance contrast and every difference in luminance between the stimulus and the background. GY reported being able to correctly name the colour stimulus as red or green on the basis of the intensities of feelings elicited by the onsets of red versus green. However, when GY was presented with a colour stimulus that was slowly uncovered or presented while his eyes were closed and then opened on command, he was unable to name the stimulus colour. When asked about this difference, he replied that when the stimulus had a sharp onset, he could detect an event, and that different events were elicited by the onsets of red and green. When there was no sharp stimulus onset, the stimuli didn't elicit any feelings.

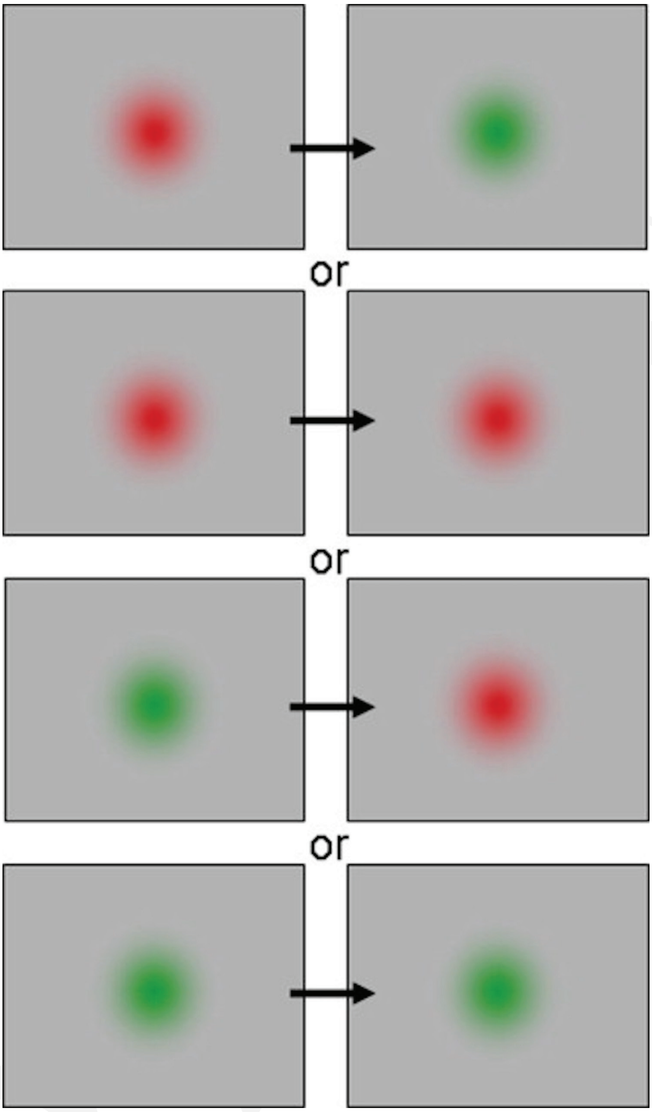

FIGURE 3.8 Examples of Gaussian patch sequences used in a colour discrimination task in a blindsight study of GY and MS.

Source: From Alexander and Cowey 2010.

A third experiment aimed at examining the role of edge detection in colour discrimination. GY was asked about whether a colour stimulus was present or not. The stimulus was either a circle with sharp edges or a Gaussian blob lacking sharp edges that was red, green, or blue against a grey background.

The stimulus onset was either sudden or would reach its peak slowly over 1s, and it would either stay on the screen until a response was made or would suddenly disappear within 200ms. The results revealed that when the stimuli had sharp edges and a sudden onset, GY was able to detect the red, green, and blue stimuli. But when the temporal onset was slow (1s), and the stimulus was either green or red, he was unable to detect the stimulus colour.

In the fourth experiment, GY was presented with a stimulus of spatially uniform colour and luminance but with a sharp chromatic edge for 200ms in one of the four quadrants of a touchscreen display on each trial. The stimulus was assigned either a positive or negative valency, and the background, which had a complementary colour, was assigned the opposite valency. GY was asked to touch the remembered position of the stimulus if it was positive and refrain from responding if it was negative. The results revealed that GY was able to detect a difference between the red and green stimuli well above chance levels, even when the luminance of the green stimulus was titrated down relative to the red stimulus. GY also performed well above chance levels when presented with a blue positive and a yellow negative. However, when the luminance of the yellow was titrated, his performance fell to chance levels.

The fifth experiment aimed to assess whether GY could detect or discriminate a range of narrow-band stimuli in his blind field. Here, GY was found to be able to discriminate and detect short, medium, and long wavelength blue, green, and red stimuli in his blind field.

Alexander and Cowey (2010) also tested a blindsight subject, MS, who sustained extensive ventral visual stream damages after a herpes infection, on simplified versions of four of the five tasks. Due to the extent of the damages to MS's ventral stream, MS performed poorly compared to GY. However, he was able to identify colour stimuli with sharp edges and detect blue/short wavelength stimuli in his blind field, but not red/long wavelength stimuli.

Taken together, the evidence indicates that successful performance in blindsight on colour detection and discrimination tasks is based on the detection of relatively simple stimulus features, such as sharp contrast edges, relative intensity, and sharp temporal colour onsets and offsets. These stimulus features seem to allow blindsight subjects to detect (spatial or temporal) colour transitions (or 'events') on the basis of the subjective salience of the colour transition (i.e., the strength or valency of the feeling elicited by the two colour stimuli).

If the intensity or valency of feelings indicated differences in colour qualities, our opponent might argue that GY's colour detection and discrimination in his blind field is mediated by (conscious) perceptual experience (cf. Morland et al. 1999). However, this is not so, or so we will argue. The mere presence of a conscious trace of a perceptually processed feature does not by itself entail that the feature is (consciously) experienced. For a perceptual representation of a feature of a stimulus to amount to a perceptual experience of that feature, the perceptual representation of that feature must make it phenomenally appear to the subject that that feature is instantiated by the stimulus. Here, we should distinguish between a visual stimulus making it phenomenally, as opposed to epistemically, appear to a subject that a certain stimulus feature is externally instantiated (Brogaard 2018; Brogaard and Gatzia in press).

To say that something epistemically appears a certain way on the basis of visual evidence is just to say that the evidence makes it probable that things are as they appear. So, clear and convincing evidence that things aren't as they appear should rationally undermine the initial appearance. By contrast, if something phenomenally appears to be a certain way, it is associated with an evidence-insensitive phenomenology. That is to say, if a thing phenomenally appears to be a certain way to a subject, then it ordinarily continues to appear that way even after acquiring evidence to the contrary (as demonstrated by the evidence-insensitivity of optical illusions such as the Müller-Lyer illusion).

Consider this analogy. At a soccer match, where the Swedish fans have painted their faces blue and yellow, whereas the Danish fans have painted their faces red and white, you may use information about face paint to discriminate between the origin of fans. But visually detecting, say, the blue and yellow face paint of a group of fans does not suffice for *perceptual experiencing* them as being of Swedish origin. Visually detecting the blue and yellow face paint of a group of fans may well make it *epistemically* appear to you that the fans are of Swedish origin, but it would not make it *phenomenally* appear that way to you. To see this, suppose you are told during halftime by a highly reliable witness that, prior to the match, the Swedish and Danish fans decided that half of the Danes and half of the Swedes would paint their faces blue and yellow and attend the match together, whereas the other half of each group would paint their faces red and white and attend the match together. In the envisaged case, even if it appeared to you that the fans with blue and yellow face paint were of Swedish origin prior to halftime, it would no longer rationally appear that way to you after you acquire the stronger defeating evidence. As it would no longer rationally appear to you that they are of Swedish origin in the face of reliable counterevidence, visually detecting the blue and yellow faces of a group of fans does not suffice for *perceptually experiencing* them as being of Swedish origin.

Analogously, visually detecting a spatial or temporal colour transition from red to green (or vice versa) on the basis of a detection of a change in a 'feeling' of something happening that is correlated with that transition isn't the same as *perceptually experiencing* something red and then something green (or vice versa). GY denied having any perceptual phenomenology with respect to a spatial or temporal transition in the colour of the stimulus, which indicates that colour information was not encoded in visual working memory in GY. Rather, what was encoded in visual working memory was GY's 'feeling' of something happening, which was a reliable marker that a spatial or temporal transition in the colour of the stimulus had occurred. So, Alexander and Cowey's (2010) findings indicate that GY lacks direct access to colour information, and that, at best, he has *mediated* access to colour information, that is, access to colour information that is mediated by direct access to a feeling of something happening (temporally or spatially).

Granted, insofar as GY had a feeling of *something* happening that corresponded to a change in the presented colour stimulus, he had an accurate (conscious) perceptual experience of something happening (temporally or spatially). But having a (conscious) perceptual experience of something happening is one thing, and having a perceptual experience of colour is quite another.[2]

To recap, the data from blindsight suggest that colour stimuli do not phenomenally appear in any way to individuals with blindsight. Blindsight subjects can sometimes access colour information indirectly via a feeling that is reliably correlated with a spatial or temporal colour transition.[3] But they have no direct access to colour information. The data pointing to colour discrimination in blindsight thus indicate that colour blindsight is a form of perception without perceptual awareness of colour, which is to say, colour blindsight is a kind of unconscious colour perception.

3.4 Colour constancy in blindsight: Concluding remarks

As we have shown, the case for the dissociation between performance and awareness, especially for low contrast, slow moving, monochrome stimuli, is strong (Weiskrantz et al. 1995; Sahraie et al. 1997; 2010; Azzopardi and Cowey 1998; Stoerig et al. 2002). The question is whether such a dissociation provides evidence for unconscious perception in blindsight. In this chapter, we have addressed arguments for thinking that all blindsight is degraded conscious perception. Some of our opponents have argued that experiments based on the signal detection theory (SDT) cannot support our conclusion that blindsight is a form of unconscious perception because the SDT framework neither explains nor seeks to explain what determines subjects' internal response to signal strength (*d'*) or how subjects set their response criterion (criterion bias). We have argued that 2AFC and 2IFC blindsight procedures can control for performance biases that may arise from the signal strength being below the minimum threshold to produce a strong internal response, for example, when a stimulus is too dim or has too low contrast to register. We have also argued that the skepticism is warranted when it comes to controlling for response biases in Yes/No tasks. However, the skepticism is not warranted when it comes to 2AFC or 2IFC tasks since controlling for the criterion bias is inherent in their design (Azzopardi and Cowey 1997, 1998).

A related argument for the thesis that all blindsight is a form of conscious vision is that the data from blindsight studies are skewed because a binary rather than a multiple-point scale is used to measure perceptual awareness

(Overgaard et al. 2008; Phillips 2021). When an appropriate scale is used to measure perceptual awareness, it is argued, blindsight is not really 'blind', but is a form of degraded conscious vision that correlates with the accuracy of the subjective reports. We have argued that the awareness detected with alternative procedures is a form of non-perceptual awareness. To back this claim, we have examined the residual visual abilities to detect and discriminate colour found in some blindsight patients, and argued that residual consciousness in blindsight is indirect and lacks the phenomenal character characteristic of conscious vision.

Chromatic contrast—which is thought to be necessary for experiencing colours despite variation in illumination—is normally processed in V1 (Kentridge et al. 2007; Norman et al. 2014). So, if blindsight patients have no functional V1, this raises the question of how to explain the finding that some of them are able to both discriminate colours in their scotoma and match colours with the same luminance presented simultaneously in their blind and normal fields (Morland et al. 1999).

One suggestion is that colour contrast is processed in extrastriate neural areas (V4 or V5/MT) in blindsight (Radoeva et al. 2008; Mundinano et al. 2019). This suggestion has received support from evidence that a visual pathway bypassing V1 and projecting instead from the LGN (located in the thalamus) to areas V4 or V5/MT (in the extrastriate cortex) may be a neural substrate of the residual visual abilities found in blindsight (e.g., Morland et al. 1999; Radoeva et al. 2008; Mundinano et al. 2019).

If colour contrast can be processed in extrastriate neural areas in some blindsight patients, this leaves open the possibility that unconscious perception in blindsight may represent surface colours and not merely the wavelength of reflected light. Even if surface colours are represented in some cases of blindsight, however, this is not to say that normal conscious colour vision and colour blindsight have the same contents. In fact, normal conscious vision and blindsight have been shown to have fundamentally different contents (Morland et al. 1999; Brogaard 2011a; Michel and Lau 2021). For example, representation of brightness in visual working memory seems to be fundamentally different in blindsight and normal conscious vision (Morland et al. 1999). Compromised brightness representation in blindsight may explain why blindsight subjects who can discriminate colour stimuli in their blind field or match colour stimuli presented in their blind and normal fields insist they have no conscious experience of colour. The radically distorted representation of brightness entails that blindsight subjects have no direct access to the colour information. Their above-chance performance in colour detection and discrimination tasks can nevertheless be explained in terms of indirect access: blindsight subjects have indirect access to colour information via a feeling that is reliably correlated with a spatial or temporal colour transition.

Indirect cognitive access to sensory information does not suffice for access consciousness, in Block's (1995) sense. Individuals with blindsight have neither phenomenal nor access consciousness. The lack of access consciousness is not merely due to the experimental prompting required for some blindsight subjects to carry out categorization tasks in their blind field but primarily to the lack of immediacy of the perceptual content (see endnote 3).

Here, it is worth keeping in mind that super-blindsight, as envisaged by Ned Block (1995), probably is biologically impossible. In super-blindsight, an individual with blindsight has full access consciousness that makes her capable of functioning like a normal sighted person, but her visual abilities are not associated with any phenomenal consciousness.

Normal visual functioning can indeed be had despite no, or virtually no, functional striate cortex, but normal visual functioning is coupled with normal perceptual awareness. In a recent case report, Mundinano et al. (2019) found that a seven-year-old child, BI, who suffered a bilateral occipital-lobe injury in the first two weeks of his life, displayed exceptional residual visual abilities in visual tasks such as contrast sensitivity, orientation and shape discrimination, colour recognition, 2D and 3D object recognition, face discrimination, and grasping. Further observations revealed that he was able to use vision to navigate his immediate environment on his own without any difficulty. He was able to play video games on his tablet, identify and track objects, manage stairs, and run around and play tag outside while avoiding obstacles. Post-injury MRIs revealed at different times a gradual deterioration of V1 and V2, eventually resulting in a complete deterioration of the right LGN-V1 pathway and an almost complete deterioration of the left. Other association cortices (extending into the parietal lobe) were also found to be absent. Even so, BI's remarkable visual abilities were found to be accompanied by visual awareness. Structural and diffusion MRI furthermore pointed to enhanced pulvinar-MT interconnectivity being the neural substrate for BI's residual visual abilities. Although spared islands of functional V1 in BI's right hemisphere may have contributed to the visual awareness accompanying his visual abilities, such spared islands cannot by themselves explain his excellent visual capacities. The pulvinar-MT pathways may thus be a neural substrate of residual visual abilities in individuals with V1 injury sustained in early childhood (Mundinano et al. 2019). But the pulvinar-MT connection normally disappears by adulthood as a result of pruning, which makes it an unlikely neural substrate of residual visual abilities in individuals whose V1 injury was sustained in adulthood, like Riddock's (1917) patients.[4]

Notes

1 ROCs are functions that allow signal strength and criterion response to be distinguished.

2 Given a combined race/choice-bias model of perception like the template tuning theory (Brogaard and Sørensen this volume), our opponent might argue that mediated (or indirect) access to colour information in blindsight can be cashed out in terms of an inexact match between the incoming signal and a best template prior to the colour transition and the incoming signal and a different best template subsequent to the colour transition. This would mean that colour blindsight is a form of degraded conscious vision after all. However, this thought betrays a misunderstanding of perceptual categorization. A feeling of something happening of the sort reported in blindsight is at best a marker of a colour shift and not a phenomenal manifestation of consecutive inexact colour categorizations.

3 Philosophers sometimes argue that perceptual experience has both a phenomenal (i.e., a 'conscious') and a non-phenomenal (i.e., a 'non-conscious') content (e.g., Chalmers 2004). For example, the phenomenal content of a visual experience of water may only involve visually perceptible qualities of water, whereas the non-phenomenal content involves the chemical structure of water. On this view, for a perceptual experience to have a certain phenomenal character just is for it to have a certain phenomenal content. So, the phenomenal character determines the phenomenal content of the experience, and the phenomenal content determines the non-phenomenal content. Although we might say that perceptual experience makes us indirectly aware of the non-phenomenal content, this is just another way of saying that we are not aware of the non-phenomenal content, as awareness is direct. An unconscious perceptual state has only non-phenomenal content. In light of this distinction, we can say that GY's 'feelings' in response to a spatial or temporal colour transition do not specify a phenomenal content of his visual perception of the transition. In fact, the only content GY's visual perception can have is a non-phenomenal content, which is just to say that his colour blindsight is a form of unconscious perception.

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References

Alexander, Iona, and Alan Cowey. 2010. "Edges, Colour and Awareness in Blindsight." *Consciousness and Cognition* 19 (2): 520–533. https://doi.org/10.1016/j.concog.2010.01.008

Azzopardi, Paul, and Alan Cowey. 1997. "Is Blindsight Like Normal, Near-threshold Vision?" *Proceedings of the National Academy of Sciences of the United States of America* 94 (25): 14190–14194. https://doi.org/10.1073/pnas.94.25.14190

Azzopardi, Paul, and Alan Cowey. 1998. "Blindsight and Visual Awareness." *Consciousness and Cognition* 7 (3): 292–311. https://doi.org/10.1006/ccog.1998.0358

Berger, Jacob, and Myrto Mylopoulos. 2019. "On Skepticism about Unconscious Perception." *Journal of Consciousness Studies* 26 (11-12): 8–32.

Block, Ned. 1995. "On a Confusion about a Function of Consciousness." *Behavioral and Brain Sciences* 18 (2): 227–247. https://doi.org/10.1017/S0140525X00038188

Boyer, Jennifer L., Stephenie Harrison, and Tony Ro. 2005. "Unconscious Processing of Orientation and Color Without Primary Visual Cortex." *Proceedings of the*

National Academy of Sciences of the United States of America 102 (46): 16875–16879. https://doi.org/10.1073/pnas.0505332102

Brent, P. J., Christopher Kennard, and Keith H. Ruddock. 1994. "Residual Colour Vision in a Human Hemianope: Spectral Responses and Colour Discrimination." *Proceedings: Biological sciences* 256 (1347): 219–225. https://doi.org/10.1098/rspb.1994.0073

Brogaard, Berit. 2011a. "Are There Unconscious Perceptual Processes?" *Consciousness and Cognition* 20 (2): 449–463. https://doi.org/10.1016/j.concog.2010.10.002

Brogaard, Berit. 2011b. "Color Experience in Blindsight?" *Philosophical Psychology* 24 (6): 767–786. https://doi.org/10.1080/09515089.2011.562641

Brogaard, Berit. 2015. "Type 2 Blindsight and the Nature of Visual Experience." *Consciousness and Cognition* 32: 92–103. https://doi.org/10.1016/j.concog.2014.09.017

Brogaard, Berit. 2018. *Seeing and Saying: The Language of Perception and the Representational View of Experience*. Oxford: Oxford University Press.

Brogaard, Berit, and Dimitria E. Gatzia (in press). "Dogmatism, Seemings, and Non-deductive Inferential Justification." In *Seemings: New Arguments, New Angles*, edited by Kevin McCain, Scott Stapleford, and Matthias Setup. New York: Routledge.

Brogaard, Berit, and Thomas A. SørensenS (in press). "Template Tuning and Graded Consciousness." In *Conscious and Unconscious Mentality: Examining Their Nature, Similarities and Differences*, edited by Juraj Hvorecký, Tomáš Marvan, and Michal Polák. London: Routledge.

Chalmers, David J. 2004. "The Representational Character of Experience." In *The Future for Philosophy*, edited by Brian Leiter, 339–380. New York: Oxford University Press.

Cowey, Alan. 2010. "The Blindsight Saga." *Experimental Brain Research* 200 (1): 3–24. https://doi.org/10.1007/s00221-009-1914-2

Cowey Alan, and Petra Stoerig. 1993. "Insights into Blindsight?" *Current Biology* 3 (4): 236–238. https://doi.org/10.1016/0960-9822(93)90343-M

Eriksen, Charles W. 1960. "Discrimination and Learning Without Awareness: A Methodological Survey and Evaluation." *Psychological Review* 67 (5): 279–300. https://doi.org/10.1037/h0041622

ffytche, Dominic H., and Semir Zeki. 2011. "The Primary Visual Cortex, and Feedback to It, Are Not Necessary for Conscious Vision." *Brain* 134 (1): 247–257. https://doi.org/10.1093/brain/awq305

Green, David M., and John A. Swets. 1966. *Signal Detection Theory and Psychophysics.* New York: Wiley.

Goodale, Melvin A., and A. David Milner. 1992. "Separate Visual Pathways for Perception and Action." *Trends in Neurosciences* 15 (1): 20–25. https://doi.org/10.1016/0166-2236(92)90344-8

Kentridge, Robert W., Charles A. Heywood, and Lawrence Weiskrantz. 2007. "Colour-contrast Processing in Human Striate Cortex." *Proceedings of the National Academy of Sciences USA* 104 (38): 15129–15131. https://doi.org/10.1073/pnas.0706603104

Macmillan, Neil A., and Douglas C. Creelman. 2005. *Detection Theory: A User's Guide.* Lawrence Erlbaum Associates Publishers.

Michel, Matthias. 2023. "How (Not) to Underestimate Unconscious Perception." *Mind & Language* 38 (2): 413–430. https://doi.org/10.1111/mila.12406

Michel, Matthias, and Hakwan Lau. 2021. “Is Blindsight Possible under Signal Detection Theory? Comment on Phillips (2021).” *Psychological Review* 128 (3): 585–591. https://doi.org/10.1037/rev0000266
Morland, Antony B., Simon R. Jones, Alison L. Finlay, Emilie Deyzac, E., Sandra Lê, and Samuel Kemp, S. 1999. “Visual Perception of Motion, Luminance and Colour in a Human Hemianope.” *Brain* 122 (Pt 6): 1183–1198. https://doi.org/10.1093/brain/122.6.1183
Mundinano, Inaki-Carril, Juan Chen, Mitchell de Souza, Marc G. Sarossy, Marc F. Joanisse, Melvyn A. Goodale, and James A. Bourne. 2019. ”More than Blindsight: Case Report of a Child with Extraordinary Visual Capacity Following Perinatal Bilateral Occipital Lobe Injury.” *Neuropsychologia* 128: 178–186. https://doi.org/10.1016/j.neuropsychologia.2017.11.017
Norman, Liam J., Kathleen Akins, Charles A. Heywood, and Robert W. Kentridge. 2014. “Color Constancy for an Unseen Surface.” *Current Biology* 24 (23): 2822–2826. https://doi.org/10.1016/j.cub.2014.10.009
Overgaard, Morten, Fehl, Katrin, Kim Mouridsen, Bo Bergholt, and Axel Cleeremans. 2008. “Seeing Without Seeing? Degraded Conscious Vision in a Blindsight Patient.” *PLoS ONE* 3 (8): e3028. https://doi.org/10.1371/journal.pone.0003028
Phillips, Ian. 2021. “Blindsight is Qualitatively Degraded Conscious Vision.” *Psychological Review* 128 (3): 558–584. https://doi.org/10.1037/rev0000254
Peters, Megan A. K., Robert W. Kentridge, Ian Phillips, and Ned Block. 2017. “Does Unconscious Perception Really Exist? Continuing the ASSC20 Debate.” *Neuroscience of Consciousness* 2017 (1): nix015. https://doi.org/10.1093/nc/nix015
Peters, Megan A. K., and Hakwan Lau, H. 2015. “Human Observers Have Optimal Introspective Access to Perceptual Processes Even for Visually Masked Stimuli.” *eLife* 4: e09651. https://doi.org/10.7554/eLife.09651
Peters, Megan A. K., Tony Ro, and Hakwan Lau, H. 2016. “Who’s Afraid of Response Bias?” *Neuroscience of Consciousness* 2016 (1): niw001. https://doi.org/10.1093/nc/niw001
Radoeva, Petya D., Sashank Prasad, David H. Brainard, and Geoffrey K. Aguirre. 2008. “Neural Activity Within Area V1 Reflects Unconscious Visual Performance in a Case of Blindsight.” *Journal of Cognitive Neuroscience* 20 (11): 1927–1939. https://doi.org/10.1162/jocn.2008.20139
Ramsøy, Thomas Z., and Morten Overgaard. 2004. “Introspection and Subliminal Perception.” *Phenomenology and the Cognitive Sciences* 3: 1–23. https://doi.org/10.1023/B:PHEN.0000041900.30172.e8
Riddoch, George. 1917. “Dissociation of Visual Perceptions Due to Occipital Injuries, with Especial Reference to Appreciation of Movement.” *Brain* 40 (1): 15–57. https://doi.org/10.1093/brain/40.1.15
Ro, Tony, Alessandro Farnè, Ruth M. Johnson, Van Wedeen, Zili Chu, Zhiyue J. Wang, Jill V. Hunter, Michael S. Beauchamp. 2007. “Feeling Sounds After a Thalamic Lesion.” *Annals of Neurology* 62 (5): 433–441. https://doi.org/10.1002/ana.21219
Sahraie, Arash, Paul B. Hibbard, Ceri T. Trevethan, and Lawrence Weiskrantz. 2010. “Consciousness of the First Order in Blindsight.” *Proceedings of the National Academy of Science, USA* 107 (49): 21217–21222 https://doi.org/10.1073/pnas.1015652107

Sahraie, Arash, Lawrence Weiskrantz, John L. Burbur, Andy Simmons, Steven C. R. Williams, and Michael J. Brammer. 1997. "Pattern of Neuronal Activity Associated with Conscious and Unconscious Processing of Visual Signals." *Proceedings of the National Academy of Science, USA* 94 (17): 9406–9411. https://doi.org/10.1073/pnas.94.17.9406

Sidis, Boris. 1898. *The Psychology of Suggestion*. New York: Appleton.

Skrzypulec, Błażej. 2022. "Contents of Unconscious Color Perception." *Review of Philosophy and Psychology* 13 (3): 665–681. https://doi.org/10.1007/s13164-021-00552-7

Stoerig, Petra, and Erhardt Barth. 2001. "Low-level Phenomenal Vision Despite Unilateral Destruction of Primary Visual Cortex." *Consciousness and Cognition* 10 (4): 574–587. https://doi.org/10.1006/ccog.2001.0526

Stoerig, Petra, Aspasia Zontanou, Alan Cowey. 2002. "Aware or Unaware: Assessment of Cortical Blindness in Four Men and a Monkey." *Cerebral Cortex* 12(6): 565–574. https://doi.org/10.1093/cercor/12.6.565

Stoerig, Petra, and Alan Cowey. 1989. "Color Blindsight. Wavelength Sensitivity in Blindsight." *Nature* 342 (6252): 916–918. https://doi.org/10.1038/342916a0

Stoerig, Petra, and Alan Cowey. 1991. "Increment-threshold Spectral Sensitivity in Blindsight: Evidence for Colour Opponency." *Brain* 114 (3): 1487–1512. https://doi.org/10.1093/brain/114.3.1487

Stoerig, Petra, and Alan Cowey. 1992. "Wavelength Discrimination in Blindsight." *Brain* 115 (Pt 2): 425–444. https://doi.org/10.1093/brain/115.2.425

Weiskrantz, Lawrence. 1986. *Blindsight—A Case Study and Implications*. Oxford: Oxford University Press.

Weiskrantz, Lawrence. 1986. "Blindsight Revisited." *Current Opinion in Neurobiology* 6 (2): 215–220. https://doi.org/10.1016/s0959-4388(96)80075-4

Weiskrantz, Lawrence, John L. Barbur, Arash Sahraie. 1995. "Parameters Affecting Conscious Versus Unconscious Visual Discrimination with Damage to the Visual Cortex (V1)." *Proceedings of the National Academy of Sciences of the United States of America* 92: 6122–6126. PMID 7597090 DOI: 10.1073/pnas.92.13.6122

Williams Jr., A. C. 1938. "Perception of Subliminal Visual Stimuli." *Journal of Psychology* 6 (1): 187–199. https://doi.org/10.1080/00223980.1938.9917596

Zeki, Semir, and Dominic H. ffytche. 1998. "The Riddock Syndrome: Insights into the Neurobiology of Conscious Vision." *Brain* 121 (Pt 1): 25–45. https://doi.org/10.1093/brain/121.1.25