Exp Brain Res (2011) 209:473–479
DOI 10.1007/s00221-011-2578-2

REVIEW

Visual experience and blindsight: a methodological review

Morten Overgaard

Received: 20 October 2010 / Accepted: 27 January 2011 / Published online: 15 February 2011

Abstract Blindsight is classically defined as residual visual capacity, e.g., to detect and identify visual stimuli, in the total absence of perceptual awareness following lesions to V1. However, whereas most experiments have investigated what blindsight patients can and cannot do, the literature contains several, often contradictory, remarks about remaining visual experience. This review examines closer these remarks as well as experiments that directly approach the nature of possibly spared visual experiences in blindsight.

Keywords Blindsight · Consciousness · Experience · Primary visual cortex

Introduction

A classical methodological remedy in cognitive neuroscience when studying mental states is to experimentally compare the state under investigation with some or several other states in order to find specific characteristics hereof, e.g., neural correlates. Researchers interested in consciousness have however had historical difficulties finding a proper "contrast" for conscious experience. How should one identify a case where the only thing different between two mental events is the presence of an accompanying conscious experience? When, for instance, presenting masked stimuli with short durations, the resulting perceptual states will most likely differ from normal vision in many ways and thus not serve as a pure contrast.

The ambition to "isolate" consciousness finding a proper "pure contrast" is typically operationalized as attempts to keep accuracy in a task constant in spite of varied subjective reports about experience. Lau and Passingham (2006) did exactly this using metacontrast masking and found that activity in the mid-dorsolateral prefrontal cortex correlated with subjects reporting that the stimulus was "seen" rather than "guessed", choosing from these two options on the computer screen. In spite of the achieved constant level of accuracy, it is debatable whether this kind of reporting and choosing whether stimuli are "seen" or "guessed" truly capture conscious versus unconscious processes in such a way that a "pure measure" and a "pure contrast" are achieved.

This paper takes onset from this discussion, examining whether blindsight counts as a "pure contrast" for conscious perception. It will be demonstrated how the blindsight literature is full of remarks of "some kind" of preserved experiences in patients, but that it is very unclear what these experiences are like. The paper will from here look closer at the methods used to determine what the patients can and cannot do and, more importantly, under which circumstances they claim to have visual, or visually derived, experiences. Based on this review, it will be argued that it is a reasonable position that blindsight may be defended as relying on "abnormal, degraded conscious vision".

Blindsight has indeed attracted much attention over decades as a candidate for a "pure contrast". It is defined as residual visual capacity without any perceptual

M. Overgaard
CNRU, Department of Communication and Psychology, Aalborg University, Kroghstraede 3, 9220 Aalborg Oest, Denmark

M. Overgaard (✉)
CNRU, MindLab, Hammel Neurorehabilitation and Research Center, Aarhus University, Noerrebrogade 44, 8000 Aarhus C, Denmark
e-mail: mortover@rm.dk

awareness (Weiskrantz 1996). Typically, blindsight patients, when prompted to do so, are able to identify visual figures and follow targets with their eyes or fingers while reporting to do so in the absence of visual consciousness following lesions to their primary visual cortex (V1).

It is difficult to decide what should count as the "starting point" of blindsight research, but already in late 19th century, researchers lesioned primary visual cortex in animals and found that aspects of visual discrimination were left intact (Ferrier 1886). In humans, some of the early experiments on intact vision in spite of occipital lesions were performed on injured soldiers, and e.g., Riddoch (1917) reported a case of a patient able to detect moving but not stationary stimuli. However, to my knowledge, the first experiment to introduce forced-choice guessing in blindsight research was performed by Pöppel et al. (1973), one year before Weiskrantz actually coined the phenomenon "blindsight". In this paper, Pöppel and co-workers examined four patients with scotomata in their visual field. They were asked to localize the position at which a visual target had appeared by moving their eyes to the position where they would guess the light was. The patients performed poorly, but nevertheless with a statistically significant accuracy. Not long after the publication of this study, Weiskrantz et al. (1974) reported five different experiments with the now famous patient DB. In the first experiment, DB was asked to shift his eyes from a fixation point to the position he would guess a light was flashed. The experiment showed a weak correspondence between target position and eye movement, much like the experiment by Pöppel, Held, and Frost. The second experiment was very much identical to the first, except DB now had to reach for the target with a finger instead of relying on eye movements alone. With this different method, results showed a very clear correspondence between target and finger position, especially for larger stimuli. Experiment three and four studied DB's ability to discriminate between two possible stimuli (X vs O, horizontal vs. vertical lines, etc.) and found that he was able to do so well above chance level with increased performance as a function of stimulus size. Experiment 5 looked at color discrimination, where DB was to decide whether red or green was presented but was inconclusive because of technical issues with stimulus control.

Blindsight and conscious experience

In themselves, the two classical experiments certainly suggest that blindsight deserves a closer investigation. The evidence has nevertheless been challenged a number of times (e.g., Campion et al. (1983)) and strongly defended even more often (e.g., Weiskrantz 2009), yet most of these discussions have centered on alternative explanations of the results, e.g., preserved islands of primary visual cortex or that light from the stimulus is scattered into the intact visual field (Campion et al. 1983; King et al. 1996). However, surprisingly little attention has been paid to the key issue what blindsight patients experience when presented with visual stimuli.

Both of the above-mentioned landmark papers have little to say about this question. Some information, however, is given in the Weiskrantz et al. (1974): When DB reported green, he said he had "a stronger feeling of something being there", and when he reported red, he "felt there was nothing there". Interestingly, even though DB did well on both trials, he was best at detecting green, indicating some relationship between the "feeling" and good performance. This also seemed to be the case in experiment 3, discriminating X and O. Here, DB had a feeling of the O being "smooth" and the X being "jagged". Although this issue was not explored further by the authors, the relationship between correct reports and such reports of "feelings" seems even more interesting than the relationship between correctness and stimulus properties, at least from the perspective of consciousness research. While DB seemed insisting that he did not "see" the stimuli, the nature of his reported "feeling" seems open for interpretation. Not least, it is an open question whether these feelings are somehow, partially or fully, visual in nature.

Today, an impressive number of experiments have been conducted on blindsight, and so it is certainly enough to conclude that the patients seem neither fully blind in a functional sense nor normally sighted (Cowey 2004, 2010). Most experiments have tried to describe the limits and possibilities in the objective performance of blindsight patients more closely. Alexander and Cowey (2010) investigated the blindsight patients MS and GY, the latter being one of the most studied patients. In five different experiments, they show that most likely, only simple stimulus features are processed in blindsight and that performance was only good when stimuli had sharp spatial boundaries.

Although such a finding could suggest that perception is degraded in blindsight, it does not imply that it is not attended. In an experiment using magnetoencephalography (MEG), Schurger et al. (2008) found that GY was significantly faster to respond correctly about a stimulus in his blind field with a prior valid cue than with an invalid cue, even though he did not report awareness of these events. Thus, mechanisms of attention seemed to operate in the absence of awareness. However, when GY sometimes did report awareness of the stimulus, it was dependent on his attentional state prior to the stimulus (responses in the gamma band to the cue). Other previous experiments have investigated the relationship between attention and visual consciousness in blindsight, e.g., Kentridge et al. (1999) who found that GY's attention could be directed by cues in the residual part of the visual field as well as in the blind field. Cues in the blind field could even direct his attention to locations in the healthy field, from which the authors conclude that spatial information selection and conscious experience rely on different processes, and that blindsight patients may have fully or partially intact visual attention without visual experience.

The discussion is important for several reasons. First of all, blindsight, if correctly interpreted as "truly blind", succeeds as a model to separate attention from consciousness, which is otherwise very methodologically difficult in healthy subjects. Furthermore, it indicates that attention and consciousness rely on different brain processes, which is also a frequently debated topic (e.g., Koch and Tsuchiya 2006). As a consequence hereof, an experimental investigation into consciousness cannot have a "pure measure" if it is confounded by variations in attention between two compared tasks.

Many experiments above demonstrate how complicated tasks blindsight patients seem able to do in the reported absence of conscious experience. It is however unclear how similar blindsight vision is to normal vision.

Azzopardi and Cowey (1997) performed a signal detection analysis on GY's yes/no-detection judgments and forced-choice detection tasks and found that his sensitivity was significantly higher during the forced-choice task. This is different from the performance of healthy subjects when having "near-threshold vision", indicating that visual stimuli in blindsight are processed "in an unusual way" (Azzopardi and Cowey 1997, p. 14190).

A few studies indicate that some of the differences between blindsight and normal vision may be exaggerated. For instance, it is typically assumed that blindsight reflects the ability to detect, localize, and discriminate whenever forced to do so. Stoerig (2010), however, showed that performance was equally accurate in two blindsight patients with and without cues. Even more striking, de Gelder et al. (2008) found intact navigation skills in patient TN who was able to walk down along corridor, avoiding barriers and turning around blockages. Such findings indicate that the typical assumption that prompting is necessary for blindsight patients to show their preserved functions is not true in all cases. Thus, this argument cannot be used to show a fundamental difference between healthy and blindsight visions.

Seemingly, the center of controversy is what the patients can do in the absence of visual conscious experiences. For this reason, it seems crucial to look closer at the methodology by way of which the "absence of conscious experiences" is established. Although lots of experiments have been performed, most experiments on humans have followed one of two paths: varieties of indirect measures or some very specific ways of using direct measures.

Indirect methods have arguably some advantages, as introspective reports about vaguely seen or totally unseen stimuli are methodologically difficult (Overgaard 2006; Cowey 2010). Famously, Marcel (1998) showed that words presented in the blind field, e.g., "bank" or "money" influenced later interpretation of a word—in this case "bank". This is interesting as it indicates that information in the blind field may be processed semantically, in opposition to several other findings that blindsight patients only process simple stimulus features (e.g., Alexander and Cowey 2010).

It is however difficult to let indirect paradigms stand alone in this field of research. The very reason one may assume that blindsight is totally "blind" is because the patients say so. If one were to disregard introspective reports as method in the study of blindsight, it seems there would be no phenomenon to study. Having said this, it is surprising how methodologically simple this aspect of the otherwise vast and ingenious literature. The great majority of blindsight studies that consider subjective reports use dichotomous measures only. That is, they ask blindsight patients whether they saw a stimulus—yes or no. In normal subjects, experiments on "near-threshold vision" have been criticized for being imprecise in their assessment of the subjective experience (Overgaard and Timmermans 2010), and it seems worthwhile to consider whether the same considerations apply in the study of blindsight.

Dichotomous or gradual measures

It is argued that dichotomous measures, simply asking subjects to say "yes" or "no" to questions about the perception of a stimulus, do not resemble the way in which it is experienced. However, "scaled" reports may also be a problem, because how should one, for instance, differentiate a "6" from a "7" on a 10-point scale? Ramsøy and Overgaard (2004) tried a different approach and asked subjects to create their own categories for subjective reports during long training sessions. They were asked what they were shown and how they experienced stimuli in terms of clarity. Subjects conformed to a four-point scale (named the Perceptual Awareness Scale, or PAS) categorized as "not seen", "weak glimpse" (meaning "something was there but I had no idea what it was"), "almost clear image", and "clear image". Ramsøy and Overgaard showed that in an experimental design where one should expect to find subliminal perception, subjects were completely at base chance when reporting "not seen". In a later study (Overgaard et al. 2006), dichotomous reports were compared directly with PAS. Using the dichotomous report, subjects showed subliminal perception, whereas none was present at PAS="not seen". Generally, PAS fitted better with objective measures such as stimulus duration and correctness than did the dichotomous report. The strongest line of evidence for the validity of the PAS scale as a reflection of conscious perception is however the subjects' own reports that it is the case. Overgaard et al. (2006) calculated for each level of PAS the percentage of cases in which subjects answered "image seen" when reporting dichotomously (but presented with identical stimulus at equal display time). The results showed that in more than 20% of the cases where subjects reported "not seen" on PAS, they responded "image seen" on the dichotomous scale. If a subject reported PAS = weak glimpse, the probability that he would answer "image seen" on the dichotomous scale was 39%. This is one of the more curious aspects of the study, indicating that different processes lie behind reporting in a dichotomous and in a "gradual" way. Even though the measures are highly different, comparisons between.

The authors conclude that subliminal perception in some cases is a methodological artifact—at least when defined as perception in the complete absence of consciousness. Given the fact that much of the blindsight literature seems to make use of dichotomous measures, it seems reasonable to re-examine the "subjective side" of the blindsight studies, even though the number of papers confirming no experience in blindsight patients is vast.

Introspective reports from blindsight patients

The blindsight literature is strewn with notes and comments about conscious experiences had by the patients during the experimental procedures. Some of these reports refer to "feelings" (e.g., Weiskrantz et al. 1974), yet others seem to refer to some sort of perceptual content, e.g., "visual pin pricks" (Richards, 1973), "dark shadows" (Barbur et al. 1980), or "white halos" (Perenin and Jeannerod 1978).

A methodologically quite interesting path was taken by Persaud and Lau (2008) in an interview with patient GY. Here, GY was asked to read philosophical definitions of the term "qualia" and afterward given a semi-structured interview regarding the presence of qualia in his blind field. During the interview, GY generally denies qualia in his blind field and reports them in his healthy field. However, where this approach could have contributed the exact information missing in many other papers, the interview, at least as reported in the paper, seems to contain no more information about GY's experiences than classical dichotomous experiments. In the end, he just reports the presence or absence of qualia. The most interesting part of the interview is in fact this:

"NP: In experimental conditions in which you are performing well (with stationary stimuli), do you have qualia in your right (affected) hemifield?

GY: Only very rarely.

NP: Can you tell me more about those rare instances when you do have qualia in your right field?

GY: That only happens on very easy trials, when the stimulus is very bright. Actually, I'm not sure I *really* have qualia then" (Persaud and Lau 2008, p. 1048).

Although this attempt to go beyond classic measures of visual consciousness in blindsight patients is admirable, it is worth noting how the questions asked, at least in the quoted material in the paper, are dichotomous, although very elaborate. "Do you have qualia?" suggests, arguably, a "yes" or "no" response. Nevertheless, GY reports to have qualia sometimes, but that he is not sure. Thus, the conclusion in the paper that GY does not have any visual experiences associated with (stationary) stimuli could seem hasty. Rather, results could be interpreted to say that the nature of experiences associated with visual stimulation in blindsight is still an unresolved issue.

In one experiment, Stoerig and Barth (2001) investigated such "feelings" in GY in order to see whether they were somehow low-level perceptual in nature. To do so, GY was asked to match a visual stimulus presented to the blind field with one of the different image transformation of the same stimulus in the healthy field. When using high-contrast stimuli, GY deemed the stimuli as "visual" and accordingly as "no match at all" compared to the "feeling" in the blind field. However, with moving stimuli, GY accepted the match as long as they were sufficiently blurred and appeared as "motion only". The results match with GY's verbal descriptions of his "feelings" as "similar to that of a normally sighted man who, with his eyes shut against sunlight, can perceive the direction of motion of a hand waved in front of him" (Beckers and Zeki 1995, p. 56). Stoerig and Barth conclude that even though GY's vision is clearly degraded and different from normal vision, his experiences are still basically visual in nature.

Such reports are rarely considered to be a challenge to the understanding and definition of blindsight as such. In stead, Weiskrantz (1998) suggests the existence of two "types" of blindsight—named type 1 and type 2. Type 2 blindsight, Weiskrantz argues, is characterized by an accompanying "feeling", while type 1 is not. This "feeling" is however by standard accounts not considered visual (and thus, as degraded visual experience) but as something else. Cowey (2004), for instance, doubts the validity the finding of Stoerig and Barth, arguing that GY is in fact comparing qualitatively different and not similar experiences.

In the experiment by Barbur et al. (1980), the blindsight patient G was asked to respond to flashing and moving targets in his blind field. G reported that the flashed targets at near-threshold illumination levels subjective appeared to him as "dark shadows", whereas the equivalent stimulation of the healthy visual field appeared bright. However, when the illumination level rose, the stimulation appeared as a localized bright flash in the "blind" field. This could, speculatively of course, be understood as a gradual "increase" in experienced perceptual clarity as a function of illumination.

Perenin and Jeannerod (1978) investigated 6 hemidecorticated patients with blindsight and compared their ability to localize the position of bright stimulus targets by hand pointing with two patients with chiasmatic lesions of the visual pathways. Control subjects could only see a glare spreading from the middle part of the screen into the normal side, whereas all hemidecorticated patients had the feeling that bright light had been turned on in the impaired part of their visual field. Interestingly, in light of the previous experiments mentioned above, none of these patients reported to "see" the form or size of the target. Furthermore, they did not report to have any conscious idea about its location, which they only "guessed" when required to respond in the tests.

Such descriptions, although often brief, should be of great interest to resolve this issue. Especially, the intuitively self-contradictory reports mentioned by Perenin and Jeannerod are of specific interest here as type 1 blindsight is defined as patients who deny seeing stimuli. Thus, all the four blindsight patients in the study should be considered "type 1". Nevertheless, considering their other reports, not only do they describe experiences related to the stimuli (as a blindsight patient "type 2" would), they use descriptions that are essentially visual. This may suggest that the patients interpret expressions such as "to see" to mean the function of seeing, or they may compare the experience of seeing in their "blind" and healthy field and find them remarkably different. This fits very well to previous studies, perhaps most clearly illustrated in the Stoerig and Barth study, or the experiment by Barbur and colleagues in which the visual experience correlates with the illumination of the stimulus. In other words, it seems a critical issue whether the subjective report of blindness is in some way dependent on the way the questions are asked.

Overgaard et al. (2008) performed a study on a 31-year-old hemianopic with left-sided injury to primary visual cortex. In the first experiment, letters were briefly flashed at different locations on a computer screen and GR's only task was to respond to every stimulus, revealing that she was blind to everything presented in the upper right quadrant. In a second experiment, GR was presented with different visual figures and asked 1) which figures were shown and 2) whether she actually saw the figure—yes or no. GR reported only very rarely that she saw stimuli in the upper right quadrant, yet she was able to report correctly about these stimuli more often than chance. In the healthy part, her reports were significant predictors of correctness, based on which the authors concluded that she had blindsight. The third experiment was identical to the second, except she now should respond with PAS rather than in a binary fashion. As a consequence, her blindsight seemingly "disappeared" in the sense that, even though she reported much more vague experiences in the upper right compared with the upper left quadrant, the relationship between correctness and reported experience was identical. All correctness above chance seemed related to vague yet conscious vision when using PAS.

This result is particularly interesting in this debate as it gives an answer to the question whether the reports of blindsight patients are dependent on the questions asked—with all the precautions, of course, relevant when concluding from a single case study. The first experiment indicates that she is a "cortically blind hemianopic", the second experiment indicates that she has blindsight, perhaps, type 1, and the third experiment indicates that she has blindsight type 2 if blindsight at all. The latter question depends on whether one would allow for experiences that are somehow visual in blindsight (as Stoerig and Barth (2001) seemingly would and Cowey (2004) seemingly would not). In other words, it seems to be the case that at least some blindsight patients have perceptual experiences in their injured field that are so different from experiences in their healthy field that they refrain from using terms such as "seeing". However, the experiences may be there, and they may be visual in some very basic sense.

Very few other experiments have manipulated the way questions about visual experiences are asked to blindsighters. Marcel (1998) did not find that patients were able to report stimuli presented to the blind field only (using dichotomous measures), yet when images presented to the blind and the healthy field simultaneously together form a pattern, the image in the blind field is seen.

Weiskrantz (2009) takes on this discussion in a paper entitled "Is blindsight just degraded normal vision?" Here, he seems open to the idea that type 2 blindsight is essentially a matter of visual yet somehow distorted experience, e.g., the experience of "afterimages" of stimuli (Weiskrantz et al. 2002). He links this phenomenon to "prime sight", the finding that DB seemingly has increased his ability to identify stimuli in his injured field—to a level that exceeds the performance of healthy subjects and his own performance in his healthy field (Trevethan et al. 2006). Interestingly, Weiskrantz (2009) mentions that DB reports visual experiences of "moving waves" in trials with higher contrast, matching increased performance. This is much in line with the interpretation based on PAS, in the above.

Concluding discussion

Based on the evidence reviewed so far, it appears difficult to argue that blindsight with certainty is either a case of residual function without any conscious experience (Cowey 2004) or a misunderstanding altogether (Campion et al. 1983). In some recent papers (Mogensen 2011; Mogensen and Mala 2009), it is argued that uninjured parts of an injured brain reorganize in such a way that an as-good-as-possible return of surface manifestations is created—including manifestations of consciousness. The plastic reorganization does not create a copy of the neural mechanisms lost to injury but rather a new mode of functioning, organized differently at lower levels.

As blindsight results from injury to primary visual cortex, central to visual perception, one would assume reorganizations that would allow for as many functional features of perception as possible as well as something "as close to vision" as possible. In other words, there may be theoretical reasons to hypothesize that patients after V1 injury have some changed or abnormal experiences related to visual stimuli. Whereas Weiskrantz answers the question in his article title "Is blindsight just degraded normal vision" with a simple "no", a plausible alternative could be that blindsight is in fact degraded yet abnormal vision. If one would embrace an interpretation of this sort, one would also deny blindsight as a plausible candidate for a "pure contrast" in the study of consciousness. Whatever position one prefers in this discussion, I believe it calls for a more detailed investigation into the possibly visual experiences in blindsight, varying experimental procedures and ways of asking questions. The results and interpretation of such experiments will be crucial to determine the status of blindsight research in the study of consciousness and neuroplasticity.

Acknowledgments Morten Overgaard was supported by a Starting Grant from the European Research Council.

References

Alexander I, Cowey A (2010) Edges, colour and awareness in blindsight. Conscious Cognit 19:520–533
Azzopardi P, Cowey A (1997) Is blindsight like normal, near-threshold vision? PNAS 94:14190–14194
Barbur J, Ruddock K, Waterfield V (1980) Human visual responses in the absence of the geniculo-calcarine projection. Brain 103:905–928
Beckers G, Zeki S (1995) The consequences of inactivating areas V1 and V5 on visual motion perception. Brain 118:49–60
Campion J, Latto R, Smith YM (1983) Is blindsight an effect of scattered light, spared cortex, and near-threshold vision? Behav Brain Sci 6:423–486
Cowey A (2004) The 30th Sir Frederick Bartlett lecture—Fact, artefact, and myth about blindsight, Q J Exp Psychol. 57(A4): 577–609
Cowey A (2010) The blindsight saga. Exp Brain Res 200:3–24
de Gelder B, Tamietto M, van Boxtel G, Goebel R, Sahraie A, van den Stock J, Stienen B, Weiskrantz L, Pegna A (2008) Intact navigation skills after bilateral loss of striate cortex. Curr Biol 18:1128–1129
Ferrier D (1886) The Functions of the Brain. Putnam
Kentridge R, Heywood C, Weiskrantz L (1999) Attention without awareness in blindsight. Proc Royal Soc London B 266:1805–1811
King MS, Azzopardi P, Cowey A, Oxbury J, Osbury S (1996) The role of light scatter in the residual visual sensitivity of patients with complete cerebral hemispherectomy. Vis Neurosci 13:1–13
Koch C, Tsuchiya N (2006) Attention and consciousness: two distinct brain processes. Trends in Cognit Sci 11:16–22
Lau H, Passingham R (2006) Relative blindsight in normal observers and the neural correlate of visual consciousness. PNAS 103:18763–18768
Marcel AJ (1998) Blindsight and shape perception: deficit of visual consciousness or of visual function? Brain 121:1565–1588
Mogensen J (2011) Reorganization of the injured brain: Implications for studies of the neural substrate of cognition and consciousness. Front Psychol 2:7
Mogensen J, Mala H (2009) Post-traumatic functional recovery and reorganization in animal models. A theoretical and methodological challenge. Scand J Psychol 50:561–573
Overgaard M (2006) Introspection in science. Conscious Cogn 15:629–633
Overgaard M, Timmermans B (2010) How unconscious is subliminal perception? In: D. Schmicking & S. Gallagher (eds) Handbook of Phenomenology and the Cognitive Sciences. Springer, New York, pp 501–519
Overgaard M, Rote J, Mouridsen K, Ramsøy TZ (2006) Is conscious perception gradual or dichotomous? A comparison of report methodologies during a visual task. Conscious Cogn 15:700–708
Overgaard M, Fehl K, Mouridsen K, Bergholt B, Cleeremans A (2008) Seeing without seeing? Degraded conscious vision in a blindsight patient. PLoS ONE 38:1–4
Perenin M, Jeannerod M (1978) Visual function within the hemianopic field following early cerebral hemidecortication in man. Neuropsychologia 16:1–13
Persaud N, Lau H (2008) Direct assessment of qualia in a blindsight participant. Conscious Cognit 17:1046–1049
Pöppel E, Held R, Frost D (1973) Residual visual function after brain wounds involving the central visual pathways in man. Nature 243:295–296
Ramsøy TZ, Overgaard M.(2004) Introspection and subliminal perception, Phenomenol Cognit Sci 3(1):1–23
Richards W (1973) Visual processing in scotomata. Exp Brain Res 17:333–347
Riddoch G (1917) Dissociations of visual perceptions due to occipital injuries, with especial reference to appreciation of movement. Brain 40:15–57
Schurger A, Cowey A, Cohen J, Treisman A, Tallon-Baudry C (2008) Distinct and independent correlates of attention and awareness in a hemianopic patient. Neuropsychologia 46:2189–2197
Stoerig P (2010) Cueless blindsight. Frontiers Hum Neurosci 374: 1–8
Stoerig P, Barth E (2001) Low-level phenomenal vision despite unilateral destruction of primary visual cortex. Conscious Cogn 10:574–587

Trevethan CT, Sahraie A, Weiskrantz L (2006) Can blindsight be superior to 'sighted-sight'? Cognition 103:491–501
Weiskrantz L (1996) Blindsight revisited. Curr Opin Neurobiol 6:215–220
Weiskrantz L (1998) Consciousness and commentaries. Towards a Science of Consciousness II, MIT Press, Cambridge
Weiskrantz L (2009) Is blindsight just degraded normal vision? Exp Brain Res 192:413–416
Weiskrantz L, Warrington E, Sanders M, Marshall J (1974) Visual capacity in the hemianopic field following a restricted occipital ablation. Brain 97:709–728
Weiskrantz L, Cowey A, Hodinott-Hill I (2002) Prime-sight in a blindsight subject. Nat Neurosci 5:101–102