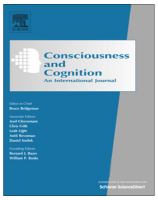
Consciousness and Cognition 22 (2013) 996–1002

Contents lists available at SciVerse ScienceDirect

Consciousness and Cognition

journal homepage: www.elsevier.com/locate/concog



More than meets the eye: Implicit perception in legally blind individuals

Alan S. Brown [a,*], Michael R. Best [a], David B. Mitchell [b]

[a] *Department of Psychology, Dedman College, Southern Methodist University, Dallas TX 75275, United States*
[b] *WellStar College, Kennesaw State University, Kennesaw, GA 30144, United States*

ARTICLE INFO

Article history:
Received 25 April 2013

Keywords:
Implicit perception
Blindsight

ABSTRACT

Legally blind participants (uncorrected vision of 20/200+) were able to identify a visual stimulus attribute (clock hand position) in the absence of consciously identifying its presence. Specifically, participants—with their corrective lenses removed—correctly guessed the hour-hand position above chance (8%) on a clockface shown on a computer screen. This occurred both when presented in a 1-clockface display (28%), as well as when shown a display containing 4 clockfaces (21%), in which only 1 face contained a hand. Even more striking, hand identification accuracy in the 4-clockface condition was comparable whether the clockface containing the hand *was* (21%) or *was not* (20%) correctly identified. That legally blind individuals are capable of identifying stimulus attributes without conscious awareness provides an additional vehicle for exploring implicit perception. Consistent with previous research, the visualsystem can apparently cope with degraded visual input through information available through a(n unconscious) secondary pathway via the superior colliculi.

1. Introduction

Research on perception without awareness has focused for many years on establishing an unambiguous empirical paradigm (Marcel, 1983; Merikle & Reingold, 1990; Mitchell, 2013). The psychophysical concept of defining an "objective" consciousness threshold has been elusive, even with signal detection, linear regression, and relative sensitivity measures (Hannula, Simons, & Cohen, 2005). Furthermore, although self-report is the clearest indication of a lack of conscious awareness, its very subjectivity raises concerns about participants' confidence and decision criteria. Indeed, subjective awareness estimates vary widely with different measures, e.g., Perceptual Awareness Scale, confidence ratings, and post-decision wagering (Sandberg, Timmermans, Overgaard, & Cleeremans, 2010).

Kihlstrom and his colleagues (Kihlstrom, 2008; Kihlstrom, Barnhardt, & Tataryn, 1992) suggested redefining subliminal vs. supraliminal perception as implicit vs. explicit perception, parallel to implicit vs. explicit memory (Mitchell, 2006; Roediger & McDermott, 1993; Schacter, 1987). Regarding an event or object "in the current environment," Kihlstrom (2008) defined implicit perception as "...any change in the person's experience, thought, or action that is attributable to such an event, in the absence of (or independent of) conscious perception of that event" (p. 588).

Kihlstrom et al. (1992) reviewed a number of paradigms used to measure implicit perception, including phenomena with normal participants (perceptual defense; hypnotic suggestion), participants with psychopathology (conversion disorders, or hysterical blindness), and patients with the neurological impairment known as "blindsight." The methodological difficulties

---

[*] Corresponding author. Address: Department of Psychology, Dedman College, Southern Methodist University, Dallas, TX 75275, United States.
E-mail address: abrown@smu.edu (A.S. Brown).

1053-8100/$ - see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.concog.2013.07.002

in this area of research range from response bias (perceptual defense; hysterical blindness) to subject selection (hypnotic suggestion). In spite of these methodological issues, research interest in implicit perception has been robust in the two decades following Kihlstrom et al.'s (1992) review. The phenomenon of "blindsight" presents a particularly compelling instance of implicit perception. Patients with primary visual cortex (V1) damage who are unable to consciously acknowledge the presence of a stimulus can nevertheless identify stimulus characteristics such as location, color, contrast, and orientation (Pöppel, Held, & Frost, 1973; Sanders, Warrington, Marshall, & Weiskrantz, 1974; Weiskrantz, 1980, 1986). Some even equate "unconscious visual processing" with blindsight in terms of the functional dissociation between awareness and performance (Marzi, Minelli, & Savazzi, 2004).

In attempting to mimic blindsight phenomena in visually intact observers, Meeres and Graves (1990) used traditional threshold setting procedures and presented an open circle subliminally (25–55 ms, followed by a pattern mask) at various locations in the visual field. When asked to identify the circle's location, participants were correct above chance even when they claimed that no stimulus was present. Blindsight in normal observers was also demonstrated by Kolb and Braun (1995) with a binocular rivalry paradigm, but their phenomenon was not replicated (Morgan, Mason, & Solomon, 1997; Robichaud & Stelmach, 2003). More recently, Lau and Passingham (2006) used metacontrast masking to produce "relative blindsight" inhealthy observers, but again, their paradigm was challenged on methodological grounds (Jannati & Di Lollo, 2012).

Related to the present investigation, Hannula et al. (2005) indicate that "observers are often under-confident about their perceptual experiences and report no awareness even when detection of stimuli by forced-choice methods is better than chance" (p. 248). This illustrates the critical dissociation between subjects' reports of their own awareness vs. their forced-choice accuracy. Hannula et al. underscored that both proponents of implicit perception and its skeptics can agree on two key points: (1) "the evidence for implicit perception cannot rely solely on participants to accurately report their state of awareness," and (2) "qualitative differences in performance can support claims of implicit perception even if they are not definitive on their own" (p. 247).

In the present research, we eschew perceptual threshold per se (whether dichotomous or continuous, cf. Overgaard, 2011) and focus instead on stimulus clarity (vs. intensity or duration), which circumvents some difficulties with prior implicit perception research. Our use of participants classified as "legally blind" addresses the first concern above regarding participants' subjective judgments of their own awareness: without their corrective lenses, their inability to see a stimulus is a genuinely objective condition. In other words, asking our participants to remove their glasses served as a proxy for setting an objective threshold. The second criterion above will emerge if these individuals exhibit qualitative differences in performance with and without their lenses. Thus, we manipulated lens maladjustment rather than stimulus duration to mimic thresholds in legally blind individuals *without* (subthreshold) and *with* (suprathreshold) their corrective lenses. We examined their ability to identify the hour hand location on a clockface.

A variety of orientation tasks were tested with D.B., the famous blindsight patient (Weiskrantz, 1986, 1987; Weiskrantz, Warrington, Sanders, & Marshall, 1974). Using forced-choice procedures, he was able to discriminate a vertical bar from a horizontal bar, the letters "X" vs. "O," a horizontal vs. a non-horizontal grating, square vs. diamond, and even "T" vs. "4." However, we reasoned that these simpler orientation tasks used by Weiskrantz and colleagues would be too easy for our subjects. The clockface has the advantage of a forced-choice paradigm, but with 12 multiple-choice answers instead of a binary decision. Also, all of our subjects were completely familiar with the basic stimulus format. In addition, based on D.B.'s performance, Weiskrantz (1986) argued that orientation "must be reckoned to be one of the most sensitive" residualcapacities (p. 72).

In the 1 clockface condition, participants simply provided the hand location. In the 4 clockface condition, participants identified both the hand location as well as the face containing the hand. Following Kihlstrom (2008), we refer to uncorrected and lens-corrected viewing conditions as implicit and explicit perception, respectively.

2. Method

2.1. Participants

A total of 23 "legally blind" individuals participated in the present investigation. They were affiliated with either Southern Methodist University or a medical facility in San Antonio, Texas. All of the participants had uncorrected vision of 20/200+ in both eyes and corrected vision (via glasses) of 20/20 in both eyes. Participants ranged in age from 20 to 49 yrs (mean = 35 yrs) and participated on a voluntary basis. Students were given extra course credit as a reward for their participation, and the IRB at both institutions approved the research.

2.2. Design

A 2 × 2 within-subjects factorial design was used, with the variables of vision (implicit, or lens uncorrected vs. explicit, or lens corrected) and clockface (1 vs. 4). On the 1 clockface trials, a single 3-in diameter clock face was presented in black in the center of a white background on a computer screen. The border of the clock was 1/8 in wide. Twelve 1/16-in wide "spokes" projected inward 3/8 in from the outer border, in locations representing the hour positions of an analog clock face. On each trial, one 1/16-in wide hand projected from the center of the clock face outward toward *one* of the 12 h positions (see Fig. 1).

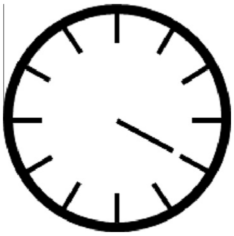


Fig. 1. Sample stimulus for the 1-clockface condition.

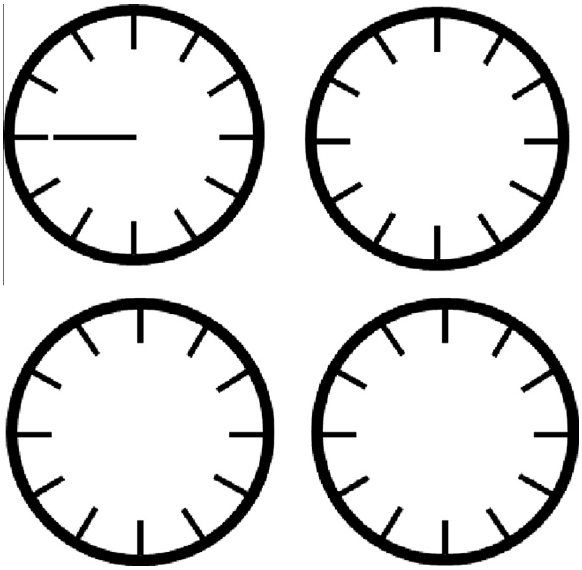


Fig. 2. Sample stimulus for the 4-clockface condition.

For the 4-clockface trials, a clock face identical to the 1-clockface condition appeared in each of four quadrants on the monitor. A hand appeared on only one of the 4 clockfaces,pointing to one of the 12 h positions (see Fig. 2). The visual angle was 10° in the 1-clockface display, and 22° in the 4-clockface display.

2.3. Procedure

Each participant was tested individually, accompanied by an experimenter who evaluated their visual acuity and initiated each trial. All responses were made orally and recorded by the experimenter. Prior to the study, the participant's visual acuity was evaluated using a Snellen derivative vision chart on the computer screen. The test established the distance each participant sat from the computer monitor so that their corrected vision was 20/20, and uncorrected vision was 20/200 or worse: legally blind in each eye according to visual disorders rules in the Federal Register (71 FR 67037, 11/20/2006). Although this applies with glasses on, our subjects had this acuity with their glasses off, so we use this term colloquially for research purposes only. The average distance between the participant's face and the computer screen was 5 ft.

PowerPoint software was used to present test stimuli on the computer screen. Participants had 10 successive trials under each of four experimental conditions (40 trials total): (a) 1 clockface implicit, without corrective lenses; (b) 1 clockface explicit, with corrective lenses; (c) 4 clockface implicit, without corrective lenses; (d) 4 clockface explicit, with corrective lenses. The trials for each condition were blocked together, and the order of blocks was randomly determined for each participant. Prior to each trial, participants focused on a point at the center of the screen, and a ready signal preceded the stimulus display by 1 s. The test stimulus appeared for 1 s, followed by a blank (white) screen. On each trial in both the 1 clockface and 4 clockface conditions, participants first indicated whether they actually saw the clock hand. If seen, they provided the hour position (1–12) that the hand was pointing to. In addition, in the 4 clockface condition they identified which clockface contained the hand. On those trials where the participant was unable to see the hand, they first guessed the hand position (1–12) in both the 1-clockface and 4-clockface conditions. In the 4-clockface conditions, participants next guessed which clockface contained the hand. Participants had templates in front of them for reference (see Fig. 3), which consisted of a single clockface without hands but with hour positions numbered around the outside, and a 4-clockface display with each face identified by letter (A, B, C, D).

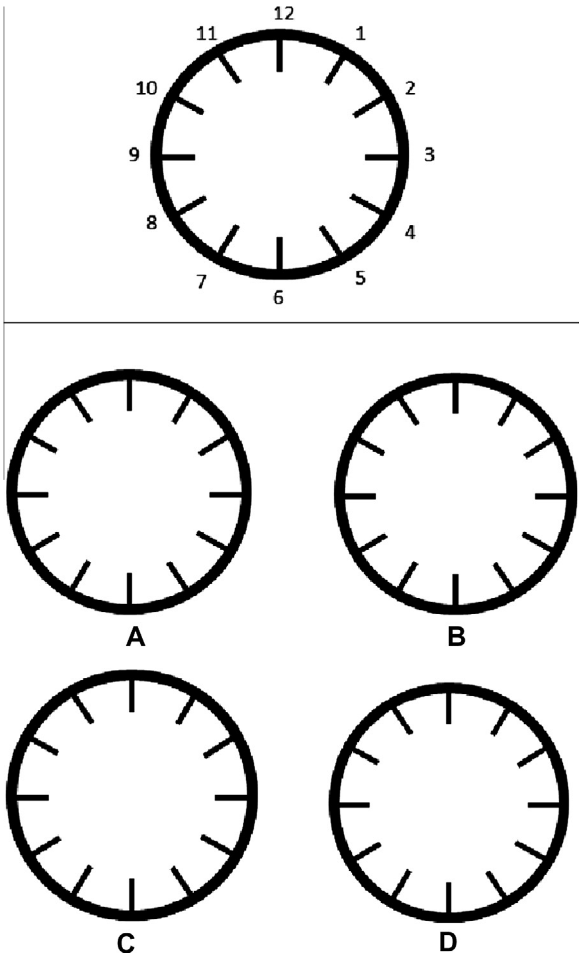


Fig. 3. Templates for identifying clock hand position and clockface location (4-clockface).

Three practice trials preceded the 10 test trials in each of the four conditions, to assure that participants (a) understood the instructions, (b) were able to detect the clock hand in the explicit condition, and (c) unable to see the clock hand in the implicit condition. In all four conditions, the hand position was randomly determined on each trial. For the 4-clockface conditions, the clockface containing the hand was also randomly determined on each trial. Participants were told that a hand would appear on all trials. Blank (catch) trials were not used in the 1-clockface condition because we established the functional absence of perceptual ability in the implicit condition via (a) preliminary visual evaluation, (b) practice trials, and (c) instructions to report any implicit trials where the clock hand was detected. However, to minimize methodological uncertainty, the 4-clockface condition served procedurally as catch trials, since 3 of the 4 clockfaces contained no hour hand.

3. Results

To keep the implicit condition uncontaminated, we excluded those trials where the participants claimed to have seen the clock hand. This happened with 12 participants, and these excluded trials comprised 4.3% of all trials in the 1-clockface implicit condition, and 3.0% in the 4-clockface implicit condition. An alpha level of .05 was used throughout.

3.1. 1-Clockface condition

As expected, correct hand identification accuracy was very high (90.4%) in the explicit condition, which was significantly above chance (1 in 12; 8.3%), $z = 15.86$. More importantly, performance in the implicit condition (27.5%) was also significantly above chance, $z = 4.82$. Thus, it appears that participants can process a visual property of a stimulus in the absence of conscious awareness of seeing it.

Implicit access to orientational information should also be evident in the pattern of errors. More specifically, errors should tend to cluster around the actual hand position. This is confirmed in Fig. 4, which plots the deviation in hand-position

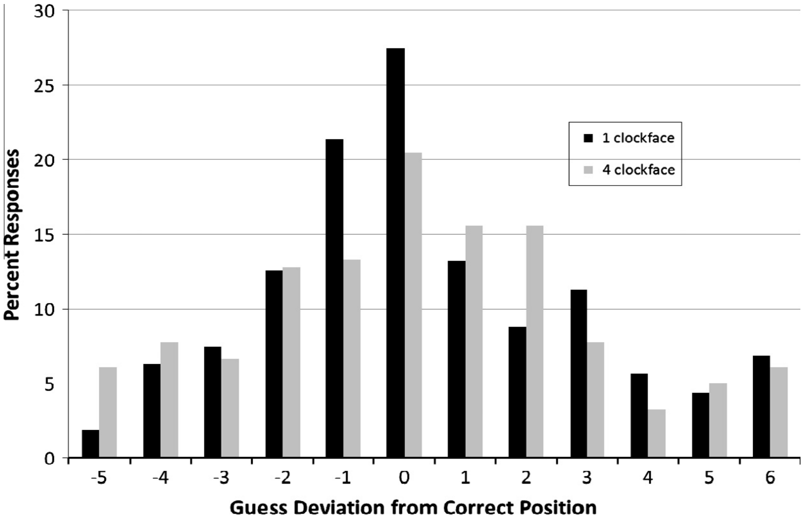


Fig. 4. Percentage of responses at each guessed hand position, in increments from the correct hand position (0).

increments between guessed and actual clock hand location. To illustrate, if the correct hand position is "4," a guess of "2" would be scored as "−2" while a guess of "9" would be scored as "+5." Fig. 4 reveals that the percentage of error responses decreases with increased separation between the guessed and actual positions in both the clockwise (+) and counterclockwise (−) directions.

Collapsing the data to reflect absolute (rather than relative) hand position deviation yielded six hand position error increments. After an arcsine transformation, the data revealed a significant linear decrease in percentage of error responses across deviations 1 through 6 in the implicit condition (12.5%, 7.7%, 6.8%, 4.2%, 2.2% and 5.0%, respectively), $F(1,22) = 38.79$, $MSe = .04$, $\eta^2 = .64$. Thus, support for the existence of implicit perception in the 1-clockface condition was found both in the above-chance hand position guessing accuracy, as well as the clustering of guesses around the correct hand position.

3.2. 4-Clockface condition

In the 4-clockface condition, participants correctly identified the clockface containing the hour hand at a level significantly above chance (25%) in the explicit (90.0%) condition, as expected, $z = 10.00$. However, guessing accuracy was not evident in the implicit condition, where performance (29.6%) did not deviate from chance, $z = 0.51$. In contrast, accuracy for hand location was significantly above chance (8.3%) in both the explicit (84.8%), $z = 14.70$, and implicit (20.5%), $z = 3.60$, conditions. In addition, the implicit condition hand identification accuracy was above chance both on those trials when face identification was correct (21.2%), $z = 3.84$, and incorrect (19.8%), $z = 3.47$, with no significant difference between these two types of trials, $F < 1$.

The distribution of hand position responses for the 4-clockface condition in Fig. 4 again reveals that the errors cluster around the correct hand position. There was a significant linear decrease in errors away from the correct position (deviation positions 1 through 6) for the implicit condition (11.4%, 11.8%, 6.0%, 4.4%, 4.6% and 4.8%, respectively), $F(1,22) = 38.69$, $MSe = 10.03$, $\eta^2 = .64$. Furthermore, this linear decrease was significant both when target clock face identification was correct (7.2%, 10.6%, 8.9%, 6.5%, 5.8%, and 0.7%, respectively), $F(1,22) = 7.99$, $MSe = 0.12$, $\eta^2 = .27$, and incorrect (12.2%, 13.0%, 4.7%, 4.0%, 3.7%, and 5.9%, respectively), $F(1,22) = 29.53$, $MSe = 0.05$, $\eta^2 = .57$. Thus, both the clockface and hand identification accuracy under the 4-clockface implicit conditions again support implicit perception. It is particularly impressive that in the implicit condition, participants can identify hand position above chance whether or not they correctly guessed which clockface contained the hand.

4. Discussion

The outcome of this investigation documents implicit perception in humans as defined by the absence of perceptual awareness due to lens maladjustment. That positional information is available without conscious recognition was supported in several ways. First, the clock hand position was identified above chance in both the 1- and 4-clockface conditions when participants reported no conscious perception of the hand (without corrective lenses). Second, the distribution of incorrect hand position guesses in the implicit conditions in both the 1- and 4-clockface conditions clustered around the correct hand position and tapered away in a systematic manner, suggesting that some fragmentary information was available to influence the guesses. Finally, the hand position guess accuracy was above chance in the 4-clockface implicit condition, whether or not the correct clockface was selected. Again, this indicates that information about the hand directionality was available even when the source location on the screen was not accessible to conscious awareness. This finding is crucial, as it demonstrates that the clock-hand positions were truly unavailable for conscious report. With the 1-clockface data alone (without catch trials), our claim would not be as strong. Since location information was at chance, but hand-pointing perception was above chance, we have clearer evidence for implicit perception. In light of the list of preserved residual capacities in blindsight (cf. Weiskrantz, 1998), the reader might wonder why localization was so difficult for our subjects. Our task was considerably more subtle: identifying *which* clock had an hour hand is harder than simply indicating *where* a light had flashed (e.g., Pöppel et al., 1973; Sanders et al., 1974; Weiskrantz, 1986; Weiskrantz et al., 1974). In addition, the dependent variables employed in the blindsight studies were more elementary: eye movements and manual reaching.

To our knowledge, this is the first demonstration of implicit (unconscious) perception among individuals with a correctable visual impairment. Participants can be functionally unperceptive, yet respond to a visual stimulus in a manner suggesting that some information is being processed. One alternative explanation for the present outcome is that participants can actually see the stimulus configuration under the implicit condition but are acquiescing to the demands of the experimenter. This argument seems unlikely for several reasons. First, one would expect the accuracy of guesses to be much higher than the range of 21–28% if participants could actually see the hand. Second, one would not expect the obtained error pattern (clustering near the correct position) if participants were faking errors. Rather, one would expect a more even distribution of errors across deviation positions. Perhaps most importantly, the probability of identifying the correct hand in the 4-clockface implicit condition was the same whether participants identified the correct face or not. Incidentally, it should also be noted that this task was moderately challenging under the best perceptual conditions, given that participants made errors on 10% of the explicit lens-corrected trials.

Nevertheless, we acknowledge the possibility that some of our subjects might have been able to make out the broad contours of the clockface. Ultimately, there is no sure way to rule this out. However—as we mentioned previously—we excluded those trials where subjects reported seeing the hand, and performance in the 4-clockface condition adds additional credence to our subjects' difficulty in consciously perceiving the stimuli. Although no one reported this, it is not inconceivable that our subjects may have been able to read the clockface from after-images. Weiskrantz, Cowey, and Hodinott-Hill (2002) reported this phenomenon in D.B., and labeled it "prime-sight." However, this seems unlikely in our subjects, as their after-images (presumably) would also suffer from poor acuity.

Although arguably not conclusive, our results have implications for the neurological and methodological debate surrounding blindsight findings (Blythe, Kennard, & Ruddock, 1987; Gazzaniga, Fendrich, & Wessinger, 1994; Overgaard, 2011; Sanders et al., 1974; Weiskrantz, 2009; Weiskrantz et al., 1974). Within the human visual system, the primary visual pathway projects from the retina to the striate visual cortex, while a secondary projection runs from the retina to the superior colliculus and finally to the extrastriate visual cortex. It has been assumed that the primary pathway handles most visual processing in humans. However, since all blindsight patients have damage to their primary striate visual cortex, Weiskrantz (1986, 1998) proposed that blindsight is mediated by a secondary visual pathway which conveysimplicit or unconscious visual information. All participants tested in the present study presumably had intact primary visual pathways, so damage to the primary pathway is not necessary to demonstrate implicit perception analogous to blindsight. In addition, recent brain imaging data (fMRI) are consistent with the theory of neocortical involvement in awareness vs. subcortical (superior colliculus) involvement for an unaware mode in normal observers (Fang & He, 2005; Hesselmann, Hebart, & Malach, 2011; Tavassoli & Ringach, 2010).

In conclusion, we have demonstrated implicit perception through impaired stimulus clarity (lens maladjustment) rather than stimulus duration to sub-threshold levels. Without corrective lenses, participants could identify the correct hand position (1- and 4-clockface conditions) above chance levels, and hand identification accuracy was above chance whether or not the face containing the clock hand was correctly located (4-clockface condition). Guessing errors clustered around the correct position, and decreased linearly away from this as the discrepancy between actual and guessed position increased. The outcome suggests that defining sub-threshold processing through lens limitations rather than exposure duration can be a viable approach to investigate implicit perception. Perhaps individuals with focusing disorders develop ways of extracting information from low frequency visual displays, and this may lead them to evolve responses to their environment that are notaccessible to their conscious awareness. Individuals with low vision often develop alternative perceptual skills known as "sensory compensation," and although this mainly comes from other modalities (e.g., auditory, tactile), there is some evidence that compensation may occur within the visual system (Cattaneo & Vecchi, 2011). Our findings imply that such dimensions of unconscious awareness may involve orientation, if not location.

Acknowledgments

We thank J.F. Kihlstrom and Cathleen Moore for valuable suggestions on an earlier draft, and Sandi Nelson for bibliographic assistance. Michael R. Best died subsequent to the completion of this research project.

References

Blythe, I. M., Kennard, C., & Ruddock, K. H. (1987). Residual vision in patients with retrogeniculate lesions of the visual pathways. *Brain, 110*, 887–905.
Cattaneo, Z., & Vecchi, T. (2011). *Blind vision: The neuroscience of visual impairment*. Cambridge, MA: MIT Press.

Fang, F., & He, S. (2005). Cortical responses to invisible objects in the human dorsal and ventral pathways. *Nature Neuroscience, 8*(10), 1380–1385.

Gazzaniga, M. S., Fendrich, R., & Wessinger, C. M. (1994). Blindsight reconsidered. *Current Directions in Psychological Science, 3*(3), 93–96.

Hannula, D. E., Simons, D. J., & Cohen, N. J. (2005). Imaging implicit perception: Promise and pitfalls. *Nature Reviews Neuroscience, 6*, 247–255.

Hesselmann, G., Hebart, M., & Malach, R. (2011). Differential BOLD activity associated with subjective and objective reports during "blindsight" in normal observers. *The Journal of Neuroscience, 31*, 12936–12944. http://dx.doi.org/10.1523/JNEUROSCI.1556-11.2011.

Jannati, A., & Di Lollo, V. (2012). Relative blindsight arises from a criterion confound in metacontrast masking: Implications for theories of consciousness. *Consciousness and Cognition, 21*, 307–314. http://dx.doi.org/10.1016/j.concog.2011.10.003.

Kihlstrom, J. F., Barnhardt, T. M., & Tataryn, D. J. (1992). Implicit perception. In R. F. Bornstein & T. S. Pittman (Eds.), *Perception without awareness* (pp. 17–54). New York: The Guilford Press.

Kihlstrom, J. F. (2008). The psychological unconscious. In O. P. John, R. W. Robins, & L. A. Pervin (Eds.), *Handbook of personality: Theory and research* (pp. 583–602). New York: The Guilford Press.

Kolb, F. C., & Braun, J. (1995). Blindsight in normal observers. *Nature, 377*, 336–338.

Lau, H. C., & Passingham, R. E. (2006). Relative blindsight in normal observers and the neural correlate of visual consciousness. *Proceedings of the National Academy of Sciences, 103*(49), 18763–18768.

Marcel, A. J. (1983). Conscious and unconscious perception: Experiments on visual masking and word recognition. *Cognitive Psychology, 15*, 197–237.

Marzi, C. A., Minelli, A., & Savazzi, S. (2004). Is blindsight in normals akin to blindsight following brain damage? *Progress in Brain Research, 144*, 295–303.

Meeres, S. L., & Graves, R. E. (1990). Localization of unseen visual stimuli by humans with normal vision. *Neuropsychologia, 28*(12), 1231–1237.

Merikle, P. M., & Reingold, E. M. (1990). Recognition and lexical decision without detection: Unconscious perception? *Journal of Experimental Psychology: Human Perception and Performance, 16*(3), 574–583.

Mitchell, D. B. (2006). Nonconscious priming after 17 years: Invulnerable implicit memory? *Psychological Science, 17*, 925–929.

Mitchell, D. B. (2013). Unconscious perception. In H. Pashler (Ed.), *Encyclopedia of the mind* (pp. 752–757). Thousand Oaks, CA: Sage Publications.

Morgan, M. J., Mason, A. J. S., & Solomon, J. A. (1997). Blindsight in normal subjects? *Nature, 385*, 401–402.

Overgaard, M. (2011). Visual experience and blindsight: A methodological review. *Experimental Brain Research, 209*, 473–479. http://dx.doi.org/10.1007/s00221-011-2578-2.

Pöppel, E., Held, R., & Frost, D. (1973). Residual visual function after brain wounds involving the central visual pathways in man. *Nature, 243*, 295–296.

Robichaud, L., & Stelmach, L. B. (2003). Inducing blindsight in normal observers. *Psychonomic Bulletin & Review, 10*, 206–209.

Roediger, H. L., III, & McDermott, K. B. (1993). Implicit memory in normal human subjects. In F. Boller & J. Grafman (Eds.). *Handbook of neuropsychology* (Vol. 8, pp. 63–131). Amsterdam: Elsevier.

Sandberg, K., Timmermans, B., Overgaard, M., & Cleeremans, A. (2010). Measuring consciousness: Is one measure better than the other? *Consciousness and Cognition, 19*, 1069–1078. http://dx.doi.org/10.1016/j.concog.2009.12.013.

Sanders, M. D., Warrington, E. K., Marshall, J., & Weiskrantz, L. (1974). 'Blindsight': Vision in a field defect. *Lancet* (April 20), 707–708.

Schacter, D. L. (1987). Implicit memory: History and current status. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13*(3), 502–518.

Tavassoli, A., & Ringach, D. L. (2010). When your eyes see more than you do. *Current Biology, 20*(3), R93–R94.

Weiskrantz, L. (1980). Varieties of residual experience. *Quarterly Journal of Experimental Biology, 32*, 365–386.

Weiskrantz, L. (1986). *Blindsight: A case study and implications*. New York: Oxford University Press – Clarendon.

Weiskrantz, L. (1987). Residual vision in a scotoma: A follow-up study of "form" discrimination. *Brain, 110*, 77–92.

Weiskrantz, L. (1998). *Blindsight: A case study and implications* (2nd ed.). Oxford: Oxford University Press.

Weiskrantz, L. (2009). Is blindsight just degraded normal vision? *Experimental Brain Research, 192*, 413–416.

Weiskrantz, L., Cowey, A., & Hodinott-Hill, I. (2002). Prime-sight in a blindsight subject. *Nature Neuroscience, 5*, 101–102.

Weiskrantz, L., Warrington, E. K., Sanders, M. D., & Marshall, J. (1974). Visual capacity in the hemianopic field following a restricted occipital ablation. *Brain, 97*, 709–728.