Published in final edited form as:
Atten Percept Psychophys. 2010 April 1; 72(3): 622–627. doi:10.3758/APP.72.3.622.

Conscious awareness of methodological choices: A reply to Milberg and McGlinchey (2010)

Marlene Behrmann,
Carnegie Mellon University, Pittsburgh, Pennsylvania

Sarah Shomstein, and
George Washington University, Washington, D.C.

Ruth Kimchi
University of Haifa, Haifa, Israel

Abstract

Milberg and McGlinchey (2010) claim that the conclusions we reach in "Perceptual Grouping Operates Independently of Attentional Selection: Evidence From Hemispatial Neglect" are unwarranted. Specifically, it is asserted that insufficient methodological control was exerted over the attentional status of the patients and that partial attention to the contralesional field could have resulted in the congruency effects we observe. Although we agree with their methodological cautions in general, we argue that our investigation is, in fact, methodologically sound. In particular, we reiterate and highlight that our investigation is unprecedented in the characterization of a patient sample with multiple clinical, psychophysical, and experimental measures; in our use of a stringent, rigidly controlled paradigm specifically designed for investigating perceptual grouping without awareness; in our modification of the experimental procedure to make it even more stringent; and in our specific methodological choices for comparison/control conditions within this experimental paradigm. We also demonstrate that partial attention to the contralesional left cannot support the robust congruency effects we observe. In light of this, we remain confident of our interpretation of our findings and suggest that perceptual grouping can indeed operate in the absence of attention.

In their critique of our article "Perceptual Grouping Operates Independently of Attentional Selection: Evidence From Hemispatial Neglect" (Shomstein, Kimchi, Hammer, & Behrmann, 2010), Milberg and McGlinchey (2010; MM) accurately capture the key characteristics of hemispatial neglect. Additionally, and rightly, they point out that this neuropsychological disorder is of great interest to vision scientists, given the dissociation between the patients' apparent perception of the visual world concurrent with their lack of conscious awareness of the very same perceptual information. The study of the extent to which perceptual information can be processed in the absence of attention and awareness has a long and contro-versial history in psychological science (Merikle, Smilek, & Eastwood, 2001; Mitroff, Simons, & Franconeri, 2002; Moore & Egeth, 1997) and in neuropsychology (Farah, 1994; Köhler & Moscovitch, 1997), and this issue is still heavily debated. It is the case, however, that MM's core criticisms of our methodological choices, including the way we characterize the attentional abilities of our neglect patients and our choice of paradigm and control/comparison conditions do not fundamentally challenge our

Correspondence concerning this article should be addressed to M. Behrmann, Department of Psychology, Carnegie Mellon University, Pittsburgh, PA 15213-3890 (behrmann@cmu.edu). .

core findings and, moreover, do not challenge our conclusion that perceptual grouping can indeed occur in the absence of attention.

Neglect As a Model for Investigating Perceptual Grouping Without Awareness

One of the longstanding problems that continues to plague researchers interested in “perception without awareness” is the difficulty in ensuring that the observer is indeed unaware of the information s/he is purported to have processed perceptually. The study of the nature and extent of perceptual processing in the contralesional field in individuals with hemispatial neglect is especially appealing, then, because it offers a methodological alternative to circumvent the need to ensure that “unattended” information is indeed “unattended.” Given that these patients do not orient to the contralesional side and that they do not volitionally report the information on the unattended side, the assumption is that they are simply not aware of this information. One can then ask how much perceptual processing takes place under these conditions of inattention.

Since the early studies of Volpe, Ledoux, and Gazzaniga (1979) and Marshall and Halligan (1988), many neuropsychological investigations have examined the fate of the unattended contralateral information, and MM and their collaborators have contributed substantially to this literature (McGlinchey-Berroth, 1997; McGlinchey-Berroth, Milberg, Verfaellie, Alexander, & Kilduff, 1993; McGlinchey-Berroth et al., 1996). Our study is conducted within this neuropsychological tradition and focuses on whether contralesional perceptual information (appearing on the left side in patients with a right-hemisphere lesion) can be grouped or organized perceptually in the absence of attention. We also explore whether the perceptual fate of this unattended information varies with the severity of the hemispatial neglect.

To address this issue, we adopt a procedure that has been extensively and successfully used in investigations that ask similar questions with normal observers. In brief, in our study, 8 patients with hemispatial neglect (diagnosed using a standardized, normed bedside battery, and confirmed and quantified using a covert spatial attentional paradigm) performed a matrix change detection task on a black and white checkerboard placed in their intact ipsilesional field. The matrix could remain the same across two successive displays, or a single square could be shifted. Concurrent with this demanding perceptual task, task-irrelevant information, consisting of grayscale circles, was presented in the contralesional field. The task-irrelevant information could either maintain the same perceptual organization from Display 1 to Display 2 (e.g., in both cases the circles would be grouped by lightness similarity into rows) or change from Display 1 to Display 2 (e.g., change from grouping into rows to grouping into columns). Note that, independent of whether the organization of the circles was maintained or not, all circles changed their grayscale value from Display 1 to Display 2 to control for the possibility that changes in organization could be detected from changes in the lightness of each circle.

Our central finding is that the reaction time in the ipsilesional matrix task is influenced by the change in or maintenance of the organization of the ignored task-irrelevant circles in the contralateral field. Thus, “same” responses to the checkerboard matrix were faster when the organization of the task-irrelevant circles remained the same (e.g., organized into rows in both Displays 1 and 2) than when the task-irrelevant organization differed (e.g., organized into rows on Display 1 but into columns on Display 2), and vice versa for task-relevant “different” responses. Not only was the extent of the congruency effect *equivalent* for the patients and the controls, but the magnitude of the congruency effect was statistically equivalent for patients who were mildly neglectful and for those who were more severely neglectful. Finally, and importantly, for all individuals, the magnitude of the congruency effect was equivalent when the task-irrelevant circles were presented in the left field and, in another control condition, in the right visual field together with the change detection matrix, demonstrating that implicit perceptual organization is as good in the unaware contralesional field as in the ipsilesional field.

MM, while acknowledging that perception might indeed occur without awareness under some conditions (as they themselves have demonstrated in the past), challenge our conclusion that patients with neglect evince perceptual grouping in the absence of attention. Moreover, they assert that we have "anosagnosia" (a condition in which a person who suffers disability seems unaware of or denies the existence of his or her disability) to methodological detail and that researchers (including us) need to be mindful of details across the entire methodological space. While MM's assertions are witty, the arguments themselves are weak. They raise two key issues, which, they suggest, prevent us from reaching our conclusion. One issue concerns the assessment of the patients' attentional abilities on a task different from that used to infer inattentional grouping, and the second is that neglect is not uniform across the neglected field and so patients may be explicitly able to process some of the supposed unattended information. We deal with each issue in turn.

Assessment and Determination of Attentional Abilities Was Established on a Task Different From That Used to Infer the Influence of Inattentional Grouping

MM argue that one cannot be confident about the status of the attentional impairment in the key experimental task (change detection/task-irrelevant grouping), because we measured the patients' attentional status on a different task using the covert spatial cuing paradigm. They bolster their claim by pointing to studies that show poor correlation among neglect tasks. Although this psychometric variability is worthy of notice, this particular point is not directly relevant here. At the outset, we note that MM refer to the fact that we assess the patients' attentional status on the covert attentional cuing paradigm and do not acknowledge that all patients in our study were initially tested on the well-known Behavioural Inattention Test as well (Wilson, Cockburn, & Halligan, 1987). The BIT is probably the most popular test for diagnosing neglect and is widely used for this purpose. It comprises nine conventional tests of neglect, it is well normed with a correlation .92 ($p < .0001$) between the subtests, and the BIT neglect score is highly correlated with the responses of clinicians to a short questionnaire, .67 ($p < .001$). One study has confirmed that seven of the nine BIT behavioral subtests differentiated significantly between subjects with visual neglect and those without neglect and, furthermore, that most of the subtests correlated significantly with the Activities of Daily Living checklist (Hartman-Maeir & Katz, 1995). These findings support the construct and predictive validity of most of the BIT behavioral subtests as functional measures of unilateral neglect.

Of note too, the covert attentional paradigm task (adopted from Posner, Snyder, & Davidson, 1980) was not used to determine simply whether the participants did or did not have neglect; that determination was made on the basis of the BIT scores. The covert attentional task was used: (1) to confirm the presence of attentional neglect with a sensitive psychophysical test, thereby increasing our confidence in the neglect diagnosis; and (2) to determine the *severity* of attentional neglect for each individual, a point that is not acknowledged by MM. We also confirmed that the BIT neglect scores and an index of attentional dysfunction (derived from the covert cuing paradigm) of the patients were highly correlated. We note, too, that previous studies have documented a strong association between clinical measures of neglect and performance on the cued attentional paradigm that we have used (Friedrich, Egly, Rafal, & Beck, 1998). There is no question, then, that the diagnosis of neglect in the patients was correct and, moreover, that the quantification of the extent of the neglect, as derived from the BIT and cuing task, was accurate and reliable. Our approach of diagnosing and quantifying the severity of the neglect impairment across multiple tasks goes well beyond what is typically done in the existing literature. With few exceptions, the characterization of neglect in existing neuropsychological studies of perception without awareness is done on the basis of lesion site, clinical observation, and/or some bedside testing (horizontal line bisection, line cancellation, figure drawing, single word reading). We are confident that we have thoroughly characterized the nature and severity of the attentional impairments in our sample of neglect patients and, therefore, that our results are *strengthened*, not weakened as MM suggest, by our findings of highly correlated impairment across both traditional and psychophysical measures of attentional abilities in the patients.

Patients Able to Detect Some Left-Sided Information

MM also claim that because the assessment of neglect is not done in the context of the detection task, we do not know about the patients' attentional status during the actual experimental paradigm. In other words, they argue that our conclusions for inattentional grouping of contralesional information are not warranted, because the neglect evinced by our patients may not be uniform across the field during the experiment itself. Thus, the patients may still have been able to utilize some of the information from the left field and this information might have given rise to the observed congruency effects. They suggest that if this is true, then the effect of contralesional information on the matrix task cannot be interpreted as evidence for processing in the absence of attention. MM appeal to several studies showing that some neglect patients are still able to detect targets placed well into the left hemifield. They also illustrate their point in a figure by showing that even partial information, such as that placed just to the left of the central midline, may have been enough to give rise to the congruency effects we report. We were well aware of this possibility when we designed the experiment and went to great lengths to constrain the paradigm and limit attention "leaking" to the neglected field. We submit that our paradigm makes it highly improbable that patients could make use of left-sided information, and that in the highly unlikely case that some attention had "leaked" through, this could not suffice to give rise to the findings we have obtained.

Experimental Changes to Limit Attentional "Leaking" to the Contralateral Field

The experimental paradigm we adopted has been used previously to demonstrate grouping in the absence of visual attention. Indeed, Driver, Davis, Russell, Turatto, and Freeman (2001) have argued that it is *only* in the context of indirect tasks such as this one (and essentially we use the same task that they did), where the observer is not directly questioned and where the limitation of self-report is circumvented, that conclusions about processing in the absence of attention can be reached. This type of matrix comparison task, in the presence of task-irrelevant distractors, has been used in other recent studies, too. In all these studies, normal participants perform a demanding change detection task on a small black-and-white matrix at fixation, and task-irrelevant background elements are arranged by color similarity into columns, rows, or simple shapes (Kimchi & Razpurker-Apfeld, 2004; Russell & Driver, 2005), or the background is composed of alternating regions organized into figures and grounds by convexity (Kimchi & Peterson, 2008). In these paradigms, as is also true in our paradigm, independent of any change in the target matrix, the perceptual organization of the background can change or remain the same across two successive displays. These studies all report that the status of the background organization influenced the speed and accuracy of change judgments for the central matrix task, even though the status of the background organization (continuity or change) could not be explicitly reported when probed with surprise questions as in Mack and Rock's (1998) inattention blindness studies. That the observers were unable to report the status of the task-irrelevant circles was taken as evidence that the observers were unaware of the perceptual organization of the background, yet congruency effects were still obtained. Crucially, these experiments were conducted with normal observers who are usually attentive to the entire field. Even though the checkerboard matrix was essentially embedded into the center of the task-irrelevant background, there is general agreement that the matrix change detection task is so absorbing/demanding and of such high attentional load (Lavie, 1995) that no attention can "leak" to the background display. In our version of the paradigm, the matrix and task-irrelevant grid were spatially separated, making it even more unlikely that the contralateral task-irrelevant information was processed. Thus, the chances of attention "leaking" to the neglected field were extra ordinarily slim.

In addition to separating the change detection matrix and the distractor grid spatially, we imposed additional, carefully controlled, constraints on our task to make it even more unlikely that the patients could process the distractors in the contralesional field. In particular, we manipulated the exposure duration of the first display of the trial (see Figure 2A in Shomstein et al., 2010) via a staircasing procedure that yielded 85% accuracy in the matrix change detection task. Thus, the observers had limited exposure to the initial display, requiring them to focus on the relevant, and not on the irrelevant, task. Additionally, we know that patients with neglect tend to be more rightward oriented in their gaze (and attention) (Behrmann, Barton, Watt, & Black, 1997; Karnath & Fetter, 1995), further ensuring their ipsilesional bias: Indeed, the average spontaneous gaze position of a group of patients with neglect was 46° to the right (Berger, Pross, Ilg, & Karnath, 2006). If this ipsilesional bias, or something akin to it, was true in our sample of patients, this further decreases the probability of the patients' processing of the distractor circles.

Furthermore, if, for argument's sake, we were to entertain the possibility that, notwithstanding the constraints of our design, patients had some residual attention to be allocated to the task-irrelevant distractor, we might have predicted modulation of the distractor congruency effect with the severity of neglect (normal, good detectors, poor detectors). As is evident from our findings, this prediction was not upheld: The extent to which task-irrelevant distractors affected target processing did not differ as a function of neglect severity in the patients, and, even more convincingly, the patients' performance was not statistically different from that of controls.

Was Any Contralateral Information Useful for Discriminating the Grids Without Invoking Perceptual Grouping?

MM concede that the *entire* task-irrelevant distractor grid might not have been processed but then ask whether partial access to the rightmost portion of the grid might have sufficed to allow the participants to discriminate between the grids and to establish whether the grids changed or remained the same across successive displays. MM provide examples of a possible scenario in which the patients have access to two adjacent dots. On MM's account, the observer need only see whether the contrast between two dots remains the same or changes in order to distinguish between the grids: If the contrast between the two dots remains the same across two successive displays, the grids remain the same, whereas if the contrast changes, the grids change. However, for the contrast between two dots to be a valid cue for distinguishing between the grids, it is necessary that the patients are indeed able to compare the contrast between the pair of dots on Display 1 and Display 2 and, critically, that they are able (under carefully titrated limited exposure) to zero in on the precise two dots in their neglected contralesional field. Let us illustrate the situation first for the rows/columns condition. Imagine, for example, that the patients focus on the two horizontally adjacent dots on the upper right corner of the distractor grid on Display 1 and Display 2 (as depicted in MM, Figure 1). In this case, the contrast between two dots might serve as a valid cue, and congruency effects could possibly arise. But what if, on some of the trials, the patients focus on adjacent dots of different orientations in successive displays—for example, on the two horizontally adjacent dots on the upper right corner on Display 1 and on the two vertically adjacent dots on the upper right corner on Display 2? In such a case, the contrast between two adjacent dots is no longer a valid cue for distinguishing between the distractor grids, because the contrast between the pair changes across successive displays when the grid organization remains the same. Thus, just detecting whether the contrast between two adjacent dots changes or remains the same is not sufficient for distinguishing between the distractor grids; the pair of two adjacent dots across successive displays needs to be of identical orientation. It follows, then, that the contrast between two adjacent dots can be a valid cue on some trials and invalid on others, depending on whether or not the patient focused on the pair in the same orientation. Nevertheless, our results showed *reliable* congruency effects in this condition.

The probability of the contrast between two adjacent dots serving as a valid cue for distinguishing between the distractor grids is even lower in the square/cross condition. In this condition, there is only one pair of horizontally adjacent dots on the rightmost portion of the distractor grid that can provide useful information—the two rightmost horizontal dots located on the midline (depicted in MM, Figure 1)—and perhaps two pairs of vertically adjacent dots located on the middle of the next to the rightmost column. No other pair of horizontally adjacent dots or vertically adjacent dots on the rightmost portion of the display, nor even the whole rightmost column, provides predictive information. Thus, in this condition, not only do the patients have to focus on the same orientation across successive displays, they also have to focus on the precise two adjacent dots that can provide the useful information. Given these constraints, the chances that the contrast between two adjacent dots in the rightmost portion of the display would serve as a valid cue on all trials are clearly low. Nonetheless, we again obtained reliable congruency effects in this condition, and most importantly, there is no difference in congruency effects between this condition and the rows/columns condition (or between cross-field and within-field trials).

It is clear then that just attending to a small, rightmost portion of the distractor grid is not sufficient for *reliably* distinguishing between the grids, particularly across conditions. Rather, the robust congruency effects that we obtained in the two organization conditions most likely arose from changes in the perceptual grouping of the distractor circles, strongly supporting our conclusion that perceptual grouping can take place in the absence of attention.

An Appropriate “Control Condition”?

MM suggest that one way we might have provided firm evidence for the absence of attention in the contralesional field would have been to create a control condition in which the patients were required to perform a task on the distractor circles in the presence of the checkerboard matrix (i.e., reversing the task). They argue that this condition would have yielded a measure of the extent of left-sided attention (or lack thereof) under the same conditions as the experimental grouping paradigm. MM themselves adopted this approach in a study in which they explored whether pictorial information presented in the neglected field was processed sufficiently well to prime lexical decision targets presented centrally (McGlinchey-Berroth et al., 1993). In addition to the patients’ completing the pictorial semantic priming task, their patients performed a control task requiring forced-choice discrimination of the very pictures used in the semantics task. The results revealed that pictures presented to the neglected field yielded faster lexical decision times to the central probe when the picture and word were related than when they were not related (semantic priming). Moreover, because, in the discrimination condition, the patients could not reliably identify the left-sided pictures, McGlinchey-Berroth et al. (1993) concluded that the neglected/unattended information can indeed be processed semantically.

In a comprehensive review on perception without awareness, Farah (1994) argued that the conclusions from McGlinchey-Berroth et al. (1993) were not definitive in and of themselves and she challenged the findings of both the experimental task and the control task. First, in semantic priming paradigms with pictures used as the prime, normal observers typically show more priming (faster reaction time for semantically related than for semantically unrelated picture primes preceding letter string probes) when the picture prime is presented in the left field than when the picture prime is presented in the right field. However, the neglect patients in the McGlinchey-Berroth et al. (1993) study showed *equal priming* from the picture primes presented to the left and to the right of fixation. The absence of the normal left field priming advantage in the neglect patients suggests that processing of neglected information in the contralesional left field might not be normal and, as such, may undermine their claim of preserved semantic processing under inattention.

It is also possible that the observed semantic facilitation might not result from the pictures' being semantically processed in the absence of attention and that an alternative mechanism might be at play. Thus, rather than the pictorial information (say, a picture of an eye in the left field) priming the lexical decision to the letter string "nose" presented centrally, it remains possible that backward priming occurred from the central letter string. On this account, the letter string "nose," represented well (given its central location), activated its semantic associates and then backwardly primed the poorly perceived pictorial information "eye" in the neglected left field. The activation of the "eye," in turn, speeded the lexical decision response time. It has previously been shown that even contralesional information that is greatly degraded by the presence of neglect can still be recovered by top-down pattern completion (akin to backward priming). Thus, activation of the letter string "nose" and its activated semantic associates can lead to pattern completion of the impoverished representation of the picture of the "eye" in the left field. This pattern completion would not occur for unrelated semantic information; the letter string "ship" has no semantic means to activate the representation of the picture of an "eye." This type of pattern completion and its ability to offset the neglect impairment has been demonstrated in empirical findings as well as in computational investigations of these neglect phenomena (Behrmann, Moscovitch, Black, & Mozer, 1990; Mozer & Behrmann, 1990).

Farah (1994) also challenged the conclusions of McGlinchey-Berroth et al. (1993) on the basis of their control condition. In the forced-choice discrimination control condition, when the pictures were on the left, the neglect patients performed roughly at chance (56%), indicating minimal, if any, discrimination of the pictorial information on the left, and supporting the claim of insufficient attention to information in the left field. However, Farah pointed out that the discrimination accuracy for the pictorial information presented in the right field was only 74%, raising concern that performance on this control task might have been limited by factors other than the neglect per se. The implication is that confirming that attention is not deployed contralesionally, under conditions that resemble those of the experimental paradigm, is not straightforward, and reaching conclusions about the true status of attention during the experimental task is not trivial.

Conclusion

In conclusion, MM caution us and other researchers about the need for extraordinarily careful attention to the sophistication of the visual system and the importance of being mindful across the entire methodological space when designing experiments to examine perception without attention. We wholeheartedly agree with these cautionary warnings, which is exactly why we were unprecedented in the characterization of our patient sample with multiple clinical, psychophysical, and experimental measures; in our use of a stringent, rigidly controlled paradigm specifically designed for investigating perceptual grouping without awareness (even in typical observers); in our modification of this procedure to make it even more stringent (staircasing the display, separating the task-relevant and task-irrelevant information); and in our specific methodological choices for comparison/control conditions within this experimental paradigm. Thus, we are confident in our findings and conclusion that perceptual grouping can occur in the absence of attention.

Acknowledgments

This work was supported by National Institute of Mental Health Grant MH54246 to M.B. and National Institute of Neurological Disorders and Stroke Grant NS07391-09 to S.S. The authors thank K. Suzanne Scherf for her useful comments.

REFERENCES

Behrmann M, Barton JJS, Watt S, Black SE. Impaired visual search in patients with unilateral neglect: An oculographic analysis. Neuropsychologia. 1997; 35:1445–1458. [PubMed: 9352522]

Behrmann M, Moscovitch M, Black SE, Mozer M. Perceptual and conceptual factors in neglect dyslexia: Two contrasting case studies. Brain. 1990; 113:1163–1183. [PubMed: 2397388]

Berger MF, Pross RD, Ilg UJ, Karnath HO. Deviation of eyes and head in acute cerebral stroke. BMC Neurology. 2006; 6:23. [PubMed: 16800885]

Driver J, Davis G, Russell C, Turatto M, Freeman E. Segmentation, attention and phenomenal visual objects. Cognition. 2001; 80:61–95. [PubMed: 11245840]

Farah, MJ. Visual perception and visual awareness after brain damage: A tutorial review. In: Umiltà, C.; Moscovitch, M., editors. Attention and performance XV: Conscious and nonconscious information processing. MIT Press, Bradford Books; Cambridge, MA: 1994. p. 37-76.

Friedrich FJ, Egly R, Rafal RD, Beck D. Spatial attention deficits in humans: A comparison of superior parietal and temporal–parietal junction lesions. Neuropsychology. 1998; 12:193–207. [PubMed: 9556766]

Hartman-Maeir A, Katz N. Validity of the Behavioral Inattention Test (BIT): Relationships with functional tasks. American Journal of Occupational Therapy. 1995; 49:507–516. [PubMed: 7645663]

Karnath HO, Fetter M. Ocular space exploration in the dark and its relation to subjective and objective body orientation in neglect patients with parietal lesions. Neuropsychologia. 1995; 33:371–377. [PubMed: 7792004]

Kimchi R, Peterson MA. Figure–ground segmentation can occur without attention. Psychological Science. 2008; 19:660–668. [PubMed: 18727781]

Kimchi R, Razpurker-Apfeld I. Perceptual grouping and attention: Not all groupings are equal. Psychonomic Bulletin & Review. 2004; 11:687–696. [PubMed: 15581119]

Köhler, S.; Moscovitch, M. Unconscious visual processing in neuropsychological syndromes: A survey of the literature and evaluation of models of consciousness. In: Rugg, M., editor. Cognitive neuroscience. MIT Press; Cambridge, MA: 1997. p. 305-373.

Lavie N. Perceptual load as a ne6cessary condition for selective attention. Journal of Experimental Psychology: Human Perception & Performance. 1995; 21:451–468. [PubMed: 7790827]

Mack, A.; Rock, I. Inattentional blindness. MIT Press; Cambridge, MA: 1998.

Marshall JC, Halligan PW. Blindsight and insight in visuo-spatial neglect. Nature. 1988; 336:766–767. [PubMed: 3205302]

McGlinchey-Berroth R. Visual information processing in hemispatial neglect. Trends in Cognitive Sciences. 1997; 1:91–97. [PubMed: 21223871]

McGlinchey-Berroth R, Milberg WP, Verfaellie M, Alexander M, Kilduff PT. Semantic processing in the neglected field: Evidence from a lexical decision task. Cognitive Neuropsychology. 1993; 10:79–108.

McGlinchey-Berroth R, Milberg WP, Verfaellie M, Grande L, D'Esposito M, Alexander M. Semantic processing and orthographic specificity in hemispatial neglect. Journal of Cognitive Neuroscience. 1996; 8:291–304.

Merikle PM, Smilek D, Eastwood JD. Perception without awareness: Perspectives from cognitive psychology. Cognition. 2001; 79:115–134. [PubMed: 11164025]

Milberg WP, McGlinchey RE. Comment on Shomstein, Kimchi, Hammer, and Behrmann (2010): A case study in methodological anosagnosia? Attention, Perception, & Psychophysics. 2010; 72:619–621.

Mitroff SR, Simons DJ, Franconeri SL. The siren song of implicit change detection. Journal of Experimental Psychology: Human Perception & Performance. 2002; 28:798–815. [PubMed: 12190251]

Moore C, Egeth H. Perception without attention: Evidence of grouping under conditions of inattention. Journal of Experimental Psychology: Human Perception & Performance. 1997; 23:339–352. [PubMed: 9103998]

Mozer MC, Behrmann M. On the interaction of selective attention and lexical knowledge: A connectionist account of neglect dyslexia. Journal of Cognitive Neuroscience. 1990; 2:96–123.

Posner MI, Snyder CR, Davidson BJ. Attention and the detection of signals. Journal of Experimental Psychology: General. 1980; 109:160–174.

Russell C, Driver J. New indirect measures of "inattentive" visual grouping in a change-detection task. Perception & Psychophysics. 2005; 67:606–623. [PubMed: 16134455]

Shomstein S, Kimchi R, Hammer M, Behrmann M. Perceptual grouping operates independently of attentional selection: Evidence from hemispatial neglect. Attention, Perception, & Psychophysics. 2010; 72:607–618.

Volpe BT, Ledoux JE, Gazzaniga MS. Information processing of visual stimuli in an "extinguished" field. Nature. 1979; 282:722–724. [PubMed: 514351]

Wilson, B.; Cockburn, J.; Halligan, PW. Behavioural Inattention Test. Thames Valley Test Co; Bury St. Edmunds: 1987.