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Note

1. Address correspondence to Alan Kingstone, 2136 West Mall, University of British Columbia, Vancouver, Canada V6T1Z4; e-mail: alan.kingstone@ubc.ca.

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Inattentional Blindness: Looking Without Seeing

Arien Mack¹

Psychology Department, New School University, New York, New York

Abstract

Surprising as it may seem, research shows that we rarely see what we are looking at unless our attention is directed to it. This phenomenon can have serious life-and-death consequences. Although the inextricable link between perceiving and attending was noted long ago by Aristotle, this phenomenon, now called inattentional blindness (IB), only recently has been named and carefully studied. Among the many questions that have been raised about IB are questions about the fate of the clearly visible, yet unseen stimuli, whether any stimuli reliably capture attention, and, if so, what they have in common. Finally, is IB an instance of rapid forgetting, or is it a failure to perceive?

Keywords

inattention; perception; awareness

Imagine an experienced pilot attempting to land an airplane on a busy runway. He pays close attention to his display console, carefully watching the airspeed indicator on his windshield to make sure he does not stall, yet he never sees that another airplane is blocking his runway!

Intuitively, one might think (and hope) that an attentive pilot would notice the airplane in time. However, in a study by Haines (1991), a few experienced pilots training in flight simulators proceeded with their landing when a clearly visible airplane was blocking the runway, unaware of the

second airplane until it was too late to avoid a collision.

As it turns out, such events are not uncommon and even may account for many car accidents resulting from distraction and inattention. This is why talking on cell telephones while driving is a distinctly bad idea. However, the pervasive assumption that the eye functions like a camera and our subjective impression of a coherent and richly detailed world lead most of us to assume that we see what there is to be seen by merely opening our eyes and looking. Perhaps this is why we are so astonished by events like the airplane scenario, although less potentially damaging instances occur every day, such as when we pass by a friend without seeing her.

These scenarios are examples of what psychologists call inattentional blindness (IB; Mack & Rock, 1998). IB denotes the failure to see highly visible objects we may be looking at directly when our attention is elsewhere. Although IB is a visual phenomenon, it has auditory and tactile counterparts as well; for example, we often do not hear something said to us if we are “not listening.”

INATTENTIONAL BLINDNESS

The idea that we miss a substantial amount of the visual world at any given time is startling even though evidence for such selective seeing was first reported in the 1970s by Neisser (1979). In one of several experiments, he asked participants to view a video of two superimposed ball-passing games in which one group of players wore white uniforms and another group wore black uniforms. Participants counted the number of passes between members of one of the groups. When the participants were subsequently asked to report what they had seen, only 21% reported the presence of a woman who had unexpectedly strolled through the basketball court carrying an open umbrella, even though she was clearly in view some of the time. Researchers recently replicated this finding with a study in which a man dressed in a gorilla costume stopped to thump his chest while walking through the court and remained visible for between 5 and 9 s (Simons & Chabris, 1999).

Although it is possible that some failures to see the gorilla or the umbrella-carrying woman might have resulted from not looking directly at them, another body of work supports the alternative explanation that the observers were so intent on counting ball passes that they missed the unexpected object that appeared in plain view. Research I have conducted with my colleagues (Mack & Rock, 1998) conclusively demonstrates that, with rare exceptions, observers generally do not see what they are looking directly at when they are attending to something else. In many of these experiments, observers fixated on specified locations while simultaneously attending to a demanding perceptual task, the object of which might be elsewhere. Under these conditions, observers often failed to

perceive a clearly visible stimulus that was located exactly where they were looking.

INATTENTIONAL BLINDNESS OR INATTENTIONAL AMNESIA?

Not surprisingly, there is a controversy over whether the types of failures documented in such experiments are really evidence that the observers did not see the stimulus, or whether they in fact saw the stimulus but then quickly forgot it. In other words, is IB more correctly described as *inattentional amnesia* (Wolfe, 1999)? Although this controversy may not lend itself to an empirical resolution, many researchers find it difficult to believe that a thumping gorilla appearing in the midst of a ball game is noticed and then immediately forgotten. What makes the argument for inattentional amnesia even more difficult to sustain is evidence that unseen stimuli are capable of priming, that is, of affecting some subsequent act. (For example, if a subject is shown some object too quickly to identify it and is then shown it again so that it is clearly visible, the subject is likely to identify it more quickly than if it had not been previously flashed. This is evidence of priming: The first exposure speeded the response to the second.) Priming can occur only if there is some memory of the stimulus, even if that memory is inaccessible.

UNCONSCIOUS PERCEPTION

A considerable amount of research has investigated unconscious, or *implicit*, perception and those perceptual processes that occur outside of awareness. This work has led many researchers to conclude that events in the envi-

ronment, even if not consciously perceived, may direct later behavior. If stimuli not seen because of IB are in fact processed but encoded outside of awareness, then it should be possible to demonstrate that they prime subsequent behavior.

The typical method for documenting implicit perception entails measuring reaction time over multiple trials. Such studies are based on the assumption that an implicitly perceived stimulus will either speed up or retard subsequent responses to relevant stimuli depending on whether the priming produces facilitation or inhibition.² However, because subjects in IB experiments cannot be made aware of the critical stimulus, unlike in many kinds of priming studies, only one trial with that stimulus is possible. This requirement rules out reaction time procedures, which demand hundreds of trials because reaction time differences tend to be small and therefore require stable response rates that can be achieved only with many trials. Fortunately, an alternate procedure, stem completion, can be used when the critical stimuli are words. In this method, some observers (experimental group) are exposed to a word in an IB procedure, and other observers (control group) are not. Then, the initial few letters of the unseen word are presented to all the observers, who are asked to complete the string of letters with one or two English words. If the members of the experimental group complete the string with the unseen word more frequently than do the members of the control group, this is taken as evidence that the experimental group implicitly perceived and encoded the word.

IB experiments using this method have demonstrated significant priming (Mack & Rock, 1998), as well as other kinds of evidence that visual information undergoes substantial processing prior to the engagement of attention. For exam-

ple, evidence that aspects of visual processing take place before attention is allocated has been provided by a series of ingenious IB experiments by Moore and her collaborators (e.g., Moore & Egeth, 1997). This work has shown that under conditions of inattention, basic perceptual processes, such as those responsible for the grouping of elements in the visual field into objects, are carried out and influence task responses even though observers are unable to report seeing the percepts that result from those processes. For example, in one study using a modification of the IB procedure, Moore and Egeth investigated the Müller-Lyer illusion, in which two lines of equal length look unequal because one has outgoing fins, which make it look longer, and the other has incoming fins, which make it look shorter. In this case, the fins were formed by the grouping of background dots: Dots forming the fins were closer together than the other dots in the background. Moore and Egeth demonstrated that subjects saw the illusion even when, because of inattention, the fins were not consciously perceived. Whatever processes priming entails, the fact that it occurs is evidence of implicit perception and the encoding of a stimulus in memory. Thus, the fact that the critical stimulus in the IB paradigm can prime subsequent responses is evidence that this stimulus is implicitly perceived and encoded.

When Do Stimuli Capture Attention and Why?

That unconsciously perceived stimuli in IB experiments undergo substantial processing in the brain is also supported by evidence that the select few stimuli able to capture attention when attention is elsewhere are complex and meaningful (e.g., the observer's name, an

iconic image of a happy face) rather than simple features like color or motion. This fact suggests that attention is captured only after the meaning of a stimulus has been analyzed. There are psychologists who believe that attention operates much earlier in the processing of sensory input, before meaning has been analyzed (e.g., Treisman, 1969). These accounts, however, do not easily explain why modest changes, such as inverting a happy face and changing one internal letter in the observer's name, which alter the apparent meaning of the stimuli but not their overall shape, cause a very large increase in IB (Mack & Rock, 1998).

Meaning and the Capture of Attention

If meaning is what captures attention, then it follows axiomatically that meaning must be analyzed before attention is captured, which is thought to occur at the end stage of the processing of sensory input. This therefore implies that even those stimuli that we are not intending to see and that do not capture our attention must be fully processed by the brain, for otherwise their meanings would be lost before they had a chance of capturing our attention and being perceived. If this is the case, then we are left with some yet-unanswered, very difficult questions. Are all the innumerable stimuli imaged on our retinas really processed for meaning and encoded into memory, and if not, which stimuli are and which are not?

Although we do not yet have answers to these questions, an unpublished doctoral dissertation by Silverman, at New School University, has demonstrated that there can be priming by more than one element in a multielement display, even when these elements cannot be reported by the subject. This finding is relevant to the question

of whether all elements in the visual field are processed and stored because up to now there has been scarcely any evidence of priming by more than one unreportable element in the field. The fact of multielement priming begins to suggest that unattended or unseen elements are processed and stored, although it says nothing about how many elements are processed and whether the meaning of all the elements is analyzed.

One answer to the question of how much of what is not seen is encoded into memory comes from an account of perceptual processing based on the assumption that perception is a limited-capacity process and that processing is mandatory up to the point that this capacity is exhausted (Lavie, 1995). According to this analysis, the extent to which unattended objects are processed is a function of the difficulty of the perceptual task (i.e., the perceptual load). When the perceptual load is high, only attended stimuli are encoded. When it is low, unattended stimuli are also processed. This account faces some difficulty because it is not clear how perceptual load should be estimated. Beyond this, however, it is difficult to reconcile this account with evidence suggesting that observers are likely to see their own names even when they occur among the stimuli that must be ignored in order to perform a demanding perceptual task (Mack, Pappas, Silverman, & Gay, 2002). It should be noted, however, that these latter results are at odds with a published report (Rees, Russell, Firth, & Driver, 1999) I describe in the next section.

EVIDENCE FROM NEURAL IMAGING

Researchers have used magnetic imaging techniques to try to

determine what happens in the brain when observers fail to detect a visual stimulus because their attention is elsewhere. Neural recording techniques may be able to show whether visual stimuli that are unconsciously perceived arouse the same areas of the brain to the same extent as visual stimuli that are seen. This is an important question because it bears directly on the nature of the processing that occurs outside of awareness prior to the engagement of attention and on the difference between the processing of attended and unattended stimuli.

In one study, Scholte, Spekreijse, and Lamme (2001) found similar neural activity related to the segregation of unattended target stimuli from their backgrounds (i.e., the grouping of the unattended stimuli so they stood out from the background on which they appeared), an operation that is thought to occur early in the processing of visual input. This activation was found regardless of whether the stimuli were attended and seen or unattended and not seen, although there was increased activation for targets that were attended and seen. This finding is consistent with the behavioral findings of Moore and Egeth (1997), cited earlier, showing that unattended, unseen stimuli undergo lower-level processing such as grouping, although the additional neural activity associated with awareness suggests that there may be important differences in processing of attended versus unattended stimuli.

In another study, Rees and his colleagues (Rees et al., 1999) used functional magnetic resonance imaging (fMRI) to picture brain activity while observers were engaged in a perceptual task. They found no evidence of any difference between the neural processing of meaningful and meaningless lexical stimuli when they were ignored, although when the same stimuli were at-

tended to and seen, the neural processing of meaningful and meaningless stimuli did differ. These results suggest that unattended stimuli are not processed for meaning. However, in another study that repeated the procedure used by Rees et al. (without fMRI recordings) but included the subject's own name among the ignored stimuli, many subjects saw their names, suggesting that meaning was in fact analyzed (Mack et al., 2002). Thus, one study shows that ignored stimuli are not semantically processed, and the other suggests that they are. This conflict remains unresolved. Are unattended, unseen words deeply processed outside of awareness, despite these fMRI results, which show no evidence of semantic neural activation by ignored words? How can one reconcile behavioral evidence of priming by lexical stimuli under conditions of inattention (Mack & Rock, 1998) with evidence that these stimuli are not semantically processed?

NEUROLOGICAL DISORDER RELATED TO INATTENTIONAL BLINDNESS

People who have experienced brain injuries that cause lesions in the parietal cortex (an area of the brain associated with attention) often exhibit what is called unilateral visual neglect, meaning that they fail to see objects located in the visual field opposite the site of the lesion. That is, for example, if the lesion is on the right, they fail to eat food on the left side of their plates or to shave the left half of their faces. Because these lesions do not cause any sensory deficits, the apparent blindness cannot be attributed to sensory causes and has been explained in terms of the role of the parietal cortex in attentional

processing (Rafal, 1998). Visual neglect therefore seems to share important similarities with IB. Both phenomena are attributed to inattention, and there is evidence that in both visual neglect (Rafal, 1998) and IB, unseen stimuli are capable of priming. In IB and visual neglect, the failure to see objects shares a common cause, namely inattention, even though in one case the inattention is produced by brain damage, and in the other the inattention is produced by the task. Thus, evidence of priming by neglected stimuli appears to be additional evidence of the processing and encoding of unattended stimuli.

ATTENTION AND PERCEPTION

IB highlights the intimate link between perception and attention, which is further underscored by recent evidence showing that unattended stimuli that share features with task-relevant stimuli are less likely to suffer IB than those that do not (Most et al., 2001). This new evidence illustrates the power of our intentions in determining what we see and what we do not.

CONCLUDING REMARKS

Although the phenomenon of IB is now well established, it remains surrounded by many unanswered questions. In addition to the almost completely unexplored question concerning whether all unattended, unseen stimuli in a complex scene are fully processed outside of awareness (and if not, which are and which are not), there is the question of whether the observer can locate where in the visual field the information extracted

from a single unseen stimulus came from, despite the fact that the observer has failed to perceive it. This possibility is suggested by the proposal that there are two separate visual systems, one dedicated to action, which does not entail consciousness, and the other dedicated to perception, which does entail consciousness (Milner & Goodale, 1995). That is, the action stream may process an unseen stimulus, including its location information, although the perception stream does not. An answer to this question would be informative about the fate of the unseen stimuli.

The pervasiveness of IB raises another unresolved question. Given that people see much less than they think they do, is the visual world a mere illusion? According to one provocative answer to this question, most recently defended by O'Regan and Noe (2001), the outcome of perceptual processing is not the construction of some internal representation; rather, seeing is a way of exploring the environment, and the outside world serves as its own external representation, eliminating the need for internal representations. Whether or not this account turns out to be viable, the phenomenon of IB has raised a host of questions, the answers to which promise to change scientists' understanding of the nature of perception. The phenomenon itself points to the serious dangers of inattention.

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Notes

1. Address correspondence to Arien Mack, Psychology Department, New School University, 65 Fifth Ave., New York, NY 10003.

2. An example of a speeded-up response (facilitation, or positive priming) has already been given. Negative, or inhibition, priming occurs when a stimulus that has been actively ignored is subsequently presented. For example, if a series of superimposed red and green shapes is rapidly presented and subjects are asked to report a feature of the red shapes, later on it is likely to take them longer to identify the green shapes than a shape that has not previously appeared, suggesting that the mental representation of the green shapes has been associated with something like an "ignore me" tag.

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