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Perception without awareness: perspectives from cognitive psychology

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Abstract

Four basic approaches that have been used to demonstrate perception without awareness are described. Each approach reflects one of two types of experimental logic and one of two possible methods for controlling awareness. The experimental logic has been either to demonstrate a dissociation between a measure of perception with awareness and a measure that is sensitive to perception without awareness or to demonstrate a qualitative difference between the consequences of perception with and without awareness. Awareness has been controlled either by manipulating the stimulus conditions or by instructing observers on how to distribute their attention. The experimental findings based on all four approaches lead to the same conclusion; namely, stimuli are perceived even when observers are unaware of the stimuli. This conclusion is supported by results of studies in which awareness has been assessed with either objective measures of forced-choice discriminations or measures based on verbalizations of subjective conscious experiences. Given this solid empirical support for the concept of perception without awareness, a direction for future research studies is to assess the functions of information perceived without awareness in determining what is perceived with awareness. The available evidence suggests that information perceived without awareness both biases *what* stimuli are perceived with awareness and influences *how* stimuli perceived with awareness are consciously experienced.

Keywords: Perception; Awareness; Perspectives; Cognitive psychology

1. Introduction

Questions regarding whether stimulus information is perceived even when there is no awareness of perceiving have been the focus of considerable research and discus-

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sion for many years. One reason for this continual interest in perception without awareness is that the very idea that perception occurs when there is no awareness of perceiving is inconsistent with the conventional belief that the perception of stimulus information capable of influencing feelings, thoughts or actions is always accompanied by an awareness of perceiving. Given this belief, any evidence that perception is not necessarily accompanied by an awareness of perceiving attracts attention because it challenges the idea that perception implies consciousness.

In the first part of this paper, we describe a conceptual framework for classifying studies of visual perception which, contrary to the conventional belief that perception implies consciousness, show that stimulus information can be perceived even when there is no awareness of perceiving. Although many different methods have been used to investigate perception without awareness, the vast majority of studies represent one of the four basic experimental approaches illustrated in Fig. 1. What the figure shows is that the studies can be classified in terms of (a) the experimental logic used to demonstrate perception without awareness and (b) the method used to control or vary awareness. By far the most frequently followed experimental logic has been to demonstrate a dissociation between two different measures of perception. One measure is assumed to assess perception *with* awareness, whereas the second measure is assumed to be sensitive to perception *without* awareness. An alternative but less frequently used experimental logic has been to contrast perception with and without awareness. The goal of these studies has been to establish qualitative differences in the consequences of perceiving with and without awareness. In studies based on either experimental logic, awareness of the critical stimuli has been controlled in one of two ways. In some studies, awareness has been controlled by manipulating the stimulus conditions, whereas in other studies, awareness has been controlled by instructing observers on how to distribute their attention. In general, the results of studies in which any of the four approaches have been

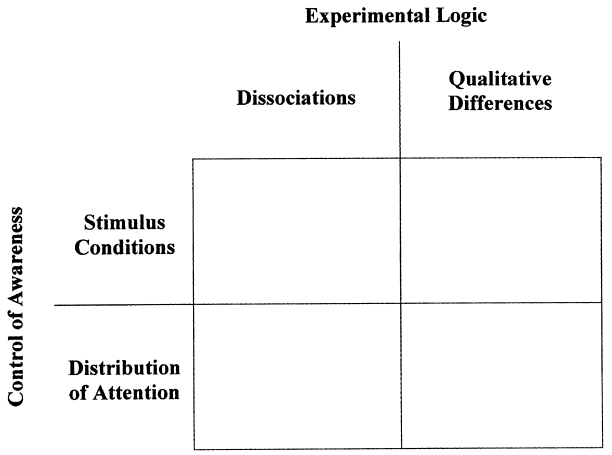

Fig. 1. Classification of studies investigating perception without awareness.

adopted show that observers can perceive critical stimuli even when they are unaware of the stimuli. Taken together, the results of these studies provide considerable evidence that perception without awareness is a valid or useful concept in the sense that it leads to verifiable predictions regarding how people perceive the world.

In the second part of the paper, we consider how information perceived without awareness influences conscious experience. The goal of the vast majority of studies to date has been simply to show that information is perceived without awareness. However, a potentially more interesting and important issue concerns how information perceived without awareness, or in other words unconsciously perceived information, influences *conscious experience*. We describe a number of studies which assess the influence of stimuli perceived without awareness on the conscious experiences associated with perceiving other visual stimuli. The results of these studies show not only that visual stimuli are perceived when there is no awareness of perceiving but that visual stimuli perceived without awareness can both bias which stimuli are perceived with awareness and influence how stimuli are consciously experienced.

2. Dissociations between measures

In the majority of studies investigating perception without awareness, the basic experimental logic has involved demonstrating a dissociation between two measures of perception. One measure is assumed to assess the stimulus information that is perceived with awareness, or in other words, conscious perception, whereas the second measure is assumed to assess the stimulus information that is perceived without awareness. The logic of using dissociations to demonstrate perception without awareness requires a demonstration of perception even under conditions where the measure of conscious perception indicates that there is no awareness of the critical stimuli.

A classic study by Sidis (1898) provides a good example of how dissociations between measures can be used to demonstrate perception without awareness. In this study, Sidis (1898) showed observers cards, each containing a single printed letter or digit. The distance between the observers and the cards was such that the observers complained that all that they could see on each card was a dim, blurred spot or nothing at all. Sidis assumed that the observers' reports of their subjective experiences when viewing the cards were good measures of conscious perception. Thus, when the observers reported either that they did not 'see' what was on the cards or that they saw nothing but dim blurred spots, Sidis assumed that the observers were unaware of perceiving either letters or digits. However, when Sidis used a second measure, forced-choice guessing, to assess whether the observers may in fact have perceived the critical stimuli that they claimed not to 'see', he found that the observers were able to guess both the category of the stimulus (i.e. letter versus digit) and the identity of the stimulus at a considerably better than chance level of performance. Thus, Sidis demonstrated a dissociation between two measures of perception. The assumed measure of conscious perception, verbal reports of

conscious perceptual experiences, indicated that the observers did not 'see' the critical stimuli, whereas his alternative measure of perception, forced-choice guessing, indicated that the observers did in fact perceive the critical stimuli. On the basis of this dissociation between the two measures of perception, Sidis concluded that he had found evidence for perception without awareness.

An important implied assumption whenever a dissociation between measures is interpreted as evidence for perception without awareness is that the measure of conscious perception provides an exhaustive measure of all relevant conscious experiences (Reingold & Merikle, 1990). For example, the study reported by Sidis only provides evidence for perception without awareness if it is assumed that the observers' verbal reports of their conscious perceptual experiences provided an accurate indication of whether the observers were aware of perceiving any aspects of the stimuli that could have possibly influenced their guesses regarding the category and identity of the stimulus items. If the observers' verbal reports of their conscious experiences were not an exhaustive measure of all relevant conscious perceptual experiences, then the dissociation between the observers' verbal reports and their guesses may simply indicate that the two measures of perception were sensitive to different aspects of consciously perceived information.

There has been considerable discussion in recent years regarding whether subjective or objective measures provide the more accurate method for assessing whether stimuli are perceived with or without awareness (for summaries of these discussions see Merikle & Reingold, 1998; Reingold & Merikle, 1990). With subjective measures, awareness is assessed on the basis of the observers' self-reports of their conscious experiences, whereas with objective measures, awareness is assessed on the basis of the observers' forced-choice decisions regarding different stimulus states. When subjective measures are used, as in the study reported by Sidis (1898), if observers report that they 'see' the critical stimuli, it is assumed that the stimuli were perceived with awareness, and if observers report that they do not see the stimuli, it is assumed that the observers were unaware of the critical stimuli. In contrast, when objective measures are used, it is assumed that any ability to discriminate between alternative stimulus states at a better than chance level of performance indicates that the stimuli were perceived with awareness, and that an inability to discriminate between alternative stimulus states indicates that the observers were unaware of any differences between the stimuli.

The primary question addressed in studies based on either subjective or objective measures of awareness is whether observers perceive stimuli even when the measure of awareness indicates that the observers are unaware of the stimuli. In the studies in which awareness has been controlled by varying the stimulus conditions, awareness has been assessed using both subjective and objective measures, whereas in the studies in which awareness has been controlled by instructing the observers on how to distribute their attention, awareness has been assessed primarily by subjective measures. The results of all the studies lead to the same conclusion. Namely, the results are unequivocal in showing that stimulus information is perceived when either subjective or objective measures indicate that the observers were unaware of the critical stimuli. Thus, despite what appear to be considerably different meth-

ods for assessing awareness, the results of studies based on either subjective or objective measures of awareness lead to the same conclusion. We suggest that in many contexts subjective measures of awareness based on self-reports and objective measures of awareness based on perceptual discriminations assess the same underlying conscious experience of perceiving.

2.1. Awareness controlled by varying stimulus conditions

The studies most often associated with the concept of perception without awareness are those studies in which the stimulus conditions have been systematically degraded until the perceived quality of the stimulus information is so poor that observers are unaware of the critical stimuli. In these studies, awareness thresholds, or in other words the minimum stimulus conditions needed to experience awareness of the critical stimuli, are first established. The critical stimuli are then presented under stimulus conditions that are even poorer than the stimulus conditions associated with the awareness thresholds to assess whether stimuli presented below the awareness threshold are perceived. Awareness thresholds in these studies have been based on both subjective and objective measures of awareness, and in the following sections we describe examples of studies which have used each type of measure.

2.1.1. Subjective measures of awareness

Some of the best examples of studies based on subjective measures of awareness come from studies of perception in the absence of awareness conducted during the late 1800s and early 1900s (for reviews and summaries see Adams, 1957; Miller, 1942). The study conducted by Sidis (1898) provides a good example of this general approach. Another good example is a study reported by Williams (1938). In this study, a circle, a triangle, or a square was projected on a screen at an intensity that was near each participant's threshold for awareness. The participants knew that just one of three possible figures would be presented on each trial and they were instructed to name "the first figure that enters your mind" (p. 191). In addition, they were instructed to indicate whether (a) they saw the figure clearly, (b) they saw something but were doubtful of their choice, or (c) they saw nothing at all and their choice was a pure guess. The results of the study showed that the participants' accuracy in naming the figures was considerably better than the chance level of performance even when they indicated they had seen nothing at all. On the basis of these results, Williams concluded "that subliminal stimuli are effective in evoking a correct response" (p. 195).

Over the years there have been many studies of perception without awareness in which subjective measures have been used to assess awareness of stimuli presented under degraded stimulus conditions. In early studies, it was established that relatively simple stimuli such as horizontal, vertical, and diagonal lines (e.g. Baker, 1937; Dunlap, 1900), circles, triangles, and squares (e.g. Miller, 1942; Williams, 1938), and letters and digits (e.g. Sidis, 1898; Stroh, Shaw, & Washburn, 1908) are perceived even when there is no awareness of perceiving. In more recent studies, it has been shown that the lexical status of letter strings (e.g. Forster & Davis, 1984;

Forster & Veres, 1998),[1] the meanings of words (e.g. Cheesman & Merikle, 1986; Merikle, Joordens, & Stolz, 1995), and the emotions expressed in faces (e.g. Esteves, Dimberg, & Öhman, 1994; Esteves & Öhman, 1993) are also perceived under conditions that do not lead to the conscious experience of perceiving. In addition, when pictures of faces expressing emotion are presented under conditions that make it impossible for observers to identify the emotional expression, functional magnetic resonance imaging (fMRI) has revealed that fearful faces lead to greater neural activity in the amygdala than happy faces (Whalen et al., 1998), and positron emission tomography (PET) has revealed that angry faces perceived without awareness lead to activation in the right amygdala but not the left amygdala (Morris, Öhman, & Dolan, 1998). Taken together, the results of both the older studies and the more recent studies provide considerable evidence that visual stimuli are perceived even when they are presented under conditions that the observers' conscious experiences lead them to report that they are unaware of the stimuli.

2.1.2. Objective measures of awareness

A widely held view is that objective measures of perceptual discriminations provide a more accurate method for determining whether or not perception is accompanied by an awareness of perceiving than is provided by subjective measures of conscious experiences. When awareness is assessed by subjective measures, there is always the concern that the observers' reports or descriptions of their conscious experiences are influenced by many factors other than their awareness of the critical stimuli (cf. Eriksen, 1960). For example, statements indicating an absence of an awareness of perceiving may reflect preconceived ideas regarding the value of particular conscious experiences for making decisions rather than a true absence of relevant conscious experiences (cf. Merikle, 1984). Given this concern regarding subjective measures of awareness, it has been suggested that awareness should always be assessed using objective measures of perceptual discriminations (e.g. Eriksen, 1960; Holender, 1986). According to this suggestion, successful discriminations between alternative stimulus states, such as the presence or absence of a stimulus, indicate awareness, whereas failures to discriminate between alternative stimulus states indicate an absence of awareness. Therefore, to demonstrate perception without awareness using objective measures, it is necessary to show that critical stimuli are perceived even when the stimulus conditions are such that the observers are unable to discriminate between alternative stimulus states.

Marcel (1974, 1983) was the first investigator to report the results of experiments showing that degraded visual stimuli are perceived even when they are presented below an objectively defined threshold for awareness. In his best known experi-

[1] Forster and his colleagues did not directly assess the participants' awareness of the critical stimuli. Rather, based on the results of pilot studies, they selected an exposure duration that did not lead to any significant subjective awareness. It was assumed that the exposure duration selected on the basis of the pilot studies prevented subjective awareness of the critical stimuli in the experiments proper. Thus, the results of the experiments reported by Forster and his colleagues are not based on direct demonstrations of dissociations between measures of awareness and other measures of perception.

ments, Marcel showed that semantic priming was produced by words that were presented under stimulus conditions that made it impossible for the observers to discriminate when a word was present from when a word was absent. These experiments were based on the finding that a target word (e.g. *doctor*) is responded to faster when it is preceded or 'primed' by a semantically related word (e.g. *nurse*) than when it is preceded or primed by a semantically unrelated word (e.g. *butter*) (e.g. Meyer & Schvaneveldt, 1976). The variation that Marcel introduced was that the perceived quality of the primes was degraded to such an extent (a visual mask, presented immediately following each prime) that the observers found it impossible to discriminate between the presence or absence of the primes. However, even though the primes were presented below this objectively defined threshold for awareness, Marcel found that semantic priming still occurred.

Many other investigators have now used Marcel's basic methodology. Not only have there been additional studies demonstrating that words presented below objectively defined thresholds prime subsequent decisions regarding consciously perceived words (e.g. Balota, 1983; Dagenbach, Carr, & Wihelmsen, 1989; Fowler, Wolford, Slade, & Tassinary, 1981; Greenwald, Draine, & Abrams, 1996; Kemp-Wheeler & Hill, 1988), but there are also studies showing that pictures presented below objectively defined thresholds prime subsequent decisions regarding words (McCauley, Parmelee, Sperber, & Carr, 1980) or pictures (Bar & Biederman, 1998). Furthermore, in a recent study in which event-related potentials (ERPs) and fMRI were used to assess neural activity, it was found that semantic analysis of unconsciously perceived primes can involve not only brain areas associated with sensory processing but also brain areas associated with motor programming of responses to the primes (Dehaene et al., 1998). The combined results from these studies based on objectively defined thresholds provide compelling evidence that visual stimuli are perceived, semantically analyzed, and responded to even when they are presented under stimulus conditions that make it difficult if not impossible for observers to discriminate between alternative stimulus states.

2.2. Awareness controlled by the distribution of attention

As an alternative to controlling awareness by varying the stimulus conditions, another method for controlling awareness is to show observers displays containing stimuli at a number of spatial locations and instruct the observers to focus their attention at just one location. Under these conditions, awareness is assessed by subjective measures; the observers are usually aware of the stimuli at the attended location, in the sense that they can correctly report these stimuli, but they are generally unaware of the stimuli at the other locations, in the sense that they report that they do not 'see' these stimuli. Thus, by presenting displays with stimuli at multiple locations and instructing observers on how to distribute their attention, it is possible to vary the observers' awareness of critical stimuli so that they are aware of the stimuli at the focus of attention and unaware of the stimuli at spatial locations outside the focus of attention.

In many respects, studies of the perception of unattended stimuli provide a better

experimental analogue of how stimuli are perceived without awareness in natural environments than is provided by studies in which awareness is controlled by varying the stimulus conditions. In studies in which the stimulus conditions are systematically degraded to reduce awareness, the stimulus conditions are so poor that even when observers focus their attention at the spatial location of the critical stimuli, it is not possible for them to become aware of the stimuli. Only in the rarest of circumstances are people ever confronted with such a situation in their natural, everyday environments. However, it is very common for people to be in situations where there are many unattended stimuli outside their immediate focus of attention which are not consciously experienced. In these situations, the unattended stimuli could be consciously experienced if the person's focus of attention changed so that it was directed toward the relevant spatial locations. For this reason, the experimental conditions in studies in which unattended stimuli are presented at spatial locations removed from the current focus of attention more closely resemble the conditions under which visual stimuli are perceived in everyday situations than the experimental conditions in studies in which degraded stimuli are presented within the focus of attention.

The studies by Mack and Rock (1998) of inattentional blindness provide good examples of experiments in which awareness has been controlled by instructing observers on how to focus their attention, and dissociations between the observers' reports of their conscious experiences and behavioral measures of perception are used to demonstrate that unattended stimuli are perceived without awareness. In one series of studies, Mack and Rock assessed the priming produced by unattended words that observers claimed not to see. The general methodology is illustrated in Fig. 2, which shows examples of the types of displays used across the first three trials of these studies. On trials 1 and 2, the observers initially viewed a fixation display for 1500 ms. The fixation display was followed by a 200 ms presentation of a display with a large cross in one quadrant, which in turn was followed by a 500 ms presenta-

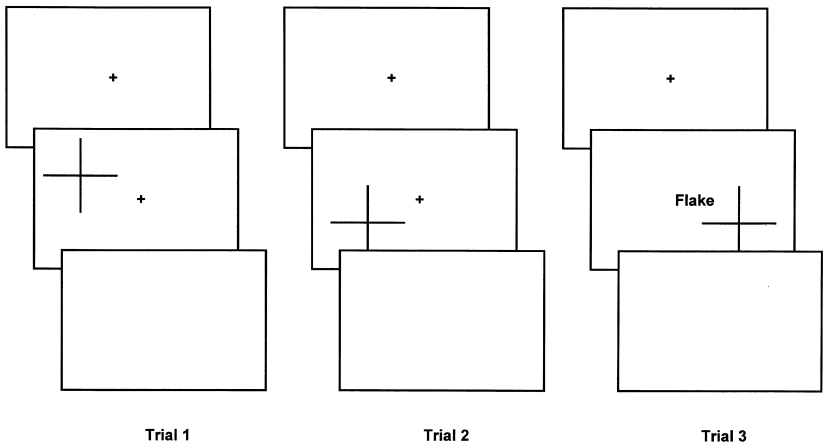

Fig. 2. Examples of the types of visual displays used by Mack and Rock (1998) to study priming.

tion of a blank display. Each cross was constructed so that either the vertical arm was longer than the horizontal arm or vice versa, and on each trial, the observers were required to report whether the horizontal or vertical arm of the cross was longer. Trial 3 was the critical trial in these experiments. On this trial, the sequence of events was the same as had occurred on trials 1 and 2, except that the display with the cross in one quadrant also contained a word located at the center of the display. Following presentation of this display, the observers first reported whether the horizontal or vertical arm of the cross was longer, and they were then asked whether they saw anything on the screen other than the cross. The surprising finding is that approximately 60% of the participants in these studies were 'blind' to the presentation of the word. When asked whether they had seen anything other than the cross, they indicated that they had noticed nothing other than the cross and that the sequence of events seemed similar to the sequence of events on the two preceding trials. Thus, based on these reports of their conscious experiences, it appears that many of the observers were unaware of the word presented at the center of the display.

To assess whether these unattended and unnoticed words were perceived despite the observers' claims that they did not 'see' these words, Mack and Rock (1998) measured whether the words primed performance on subsequent tests of forced-choice recognition and stem completion. For forced-choice recognition, the observers were presented with an array of five words and asked to select the word that had been presented. It was found that approximately 47% of the observers who were 'blind' to the presence of the word actually perceived sufficient information to chose the correct word. For stem completion, Mack and Rock presented the first three letters of the word that the observers claimed not to have seen (e.g. *flake*) and asked the observers to complete the word stem (e.g. *fla*) with the first two English words that came to mind. The results indicated that 36% of the 'blind' observers used the presented word (e.g. *flake*) as one of their two completions, which was considerably higher than the baseline level of performance (i.e. 4%) exhibited by control subjects. These findings clearly show that despite the observers' claims that they were unaware of the unattended words, sufficient information was perceived regarding the words to influence their performance on subsequent tests of forced-choice recognition and stem completion.

The studies conducted by Mack and Rock (1998) provide some of the most compelling evidence to date that *unattended* words can be perceived without awareness. Although there is a long history of studies investigating the perception of unattended visual stimuli (see Johnson & Dark, 1986 for a review), in the vast majority of these studies no attempt was made to assess the participants' awareness of the unattended stimuli. Thus, it was not possible in these studies to demonstrate a dissociation between a measure of awareness and a measure of performance. In contrast, because Mack and Rock assessed both the perceptual experiences associated with perceiving the unattended words and the priming produced by the unattended words, it was possible for them to demonstrate that the unattended words primed performance on subsequent tasks even when the observers' reports of their perceptual experiences suggested that the unattended words were not perceived. The dissociations found by Mack and Rock are very similar to the

dissociations found in studies in which awareness thresholds have been based on subjective measures and awareness has been controlled by varying the stimulus conditions. As such, the findings reported by Mack and Rock provide additional evidence that visual stimuli are perceived even when the observers' perceptual experiences lead them to report that they did not 'see' the stimuli.

2.3. Subjective versus objective measures of awareness

Studies based on subjective and objective measures of awareness assess awareness in what appear to be very different ways. The most striking difference between the two types of studies are the different assumptions regarding performance on forced-choice tasks. In studies based on subjective measures of awareness, correct forced-choice performance is assumed to reflect the perception of stimulus information in the *absence* of any awareness of perceiving. In contrast, in studies based on objective measures of awareness, correct forced-choice performance is often assumed to reflect the *presence* of an awareness of perceiving (e.g. Holender, 1986). Despite these very different assumptions regarding correct forced-choice performance, the results from studies based on subjective and objective measures of awareness lead to similar conclusions. These findings raise the issue of how it is possible to reach such similar conclusions when awareness is assessed in such different ways.

The reason that studies based on subjective and objective measures of awareness lead to similar conclusions may be simply that objective measures provide a more conservative estimate than subjective measures of the minimum stimulus conditions needed to perceive a stimulus with awareness.[2] In studies based on objective measures of awareness, it is assumed that a failure to discriminate between alternative stimuli indicates that the observers are unaware of the characteristics that distinguish the stimuli. This is a relatively non-controversial assumption. However, it does not imply, as is often assumed (e.g. Assad, 1999; Holender, 1986), that success in discriminating between alternative stimuli necessarily indicates awareness of the perceptual characteristics that distinguish the stimuli. In other words, the assumption that a failure to discriminate between alternative stimuli indicates an absence of awareness is not necessarily inconsistent with the possibility that correct forced-choice discriminations may also occur even when perception is not accompanied by an awareness of perceiving. In fact, the only direct evidence regarding whether or not correct forced-choice performance occurs when there is no awareness of perceiving comes from studies in which awareness has been assessed using subjective measures. The results of these studies clearly show that correct forced-choice performance can occur even when there is no awareness of perceiving. Viewed in this way, it is not inconsistent to view objective and subjective measures as two different but complementary methods for establishing the minimal stimulus conditions needed to be aware of critical stimuli. The primary difference between

[2] For a discussion of other possible reasons why studies based on subjective and objective measures of awareness lead to similar conclusions, see Merikle and Daneman (2000).

the two methods is that the minimal stimulus conditions established with objective measures are typically poorer or more limited than the minimal stimulus conditions established with subjective measures. However, even though objective measures may provide more conservative estimates than subjective measures of the minimal stimulus conditions needed to perceive critical stimuli with awareness, observers may be unaware of critical stimuli presented under the stimulus conditions established using either subjective or objective measures. Thus, there may be no necessary contradiction between using measures of forced-choice performance both to define the minimal stimulus conditions needed to perceive critical stimuli with awareness and to assess perception in the absence of awareness. In many instances, measures of forced-choice performance may simply provide a conservative method for determining whether perception is accompanied by the experience of perceiving.

If the primary difference between objective and subjective measures of awareness is that objective measures provide more conservative estimates than subjective measures of the minimal stimulus conditions necessary to perceive critical stimuli with awareness, the obvious question that arises is which measure is the better measure to use in studies of perception without awareness? The advantage of using objective measures is that by establishing the stimulus conditions that make it impossible for observers to discriminate between alternative stimuli, it is possible to obtain data that provide intuitively compelling demonstrations of perception without awareness. The demonstrations are compelling because it is implausible to assume that observers are aware of critical stimuli when they find it impossible to discriminate between the stimuli. However, as the basis for a general approach to the study of perception without awareness, objective measures have a serious limitation. Unless it is possible to find objective measures that assess perception with awareness *exclusively*, any approach based on objective measures of awareness will lead to an underestimation of the influence of information perceived without awareness (Merikle & Reingold, 1998). Given that all measures of perception can in principle be influenced both by information perceived with awareness and by information perceived without awareness, the minimal stimulus conditions established using objective measures will not only reduce the likelihood of perception with awareness but will also reduce the likelihood of perception without awareness. For this reason, we suggest that subjective measures should be the preferred means for assessing the presence or absence of awareness. Even though there is a justified uneasiness about using subjective measures of awareness as the basis for distinguishing perception with awareness from perception without awareness, when all things are considered, self-reports of conscious experiences can provide both a direct and an accurate indication of the presence or absence of an awareness of perceiving (cf. Chalmers, 1996; Merikle, 1992).

3. Contrasts between perception with and without awareness

As an alternative to establishing dissociations between measures, it is also possible to demonstrate perception without awareness using a single measure of percep-

tion, if there are theoretical/conceptual reasons to believe that the selected measure will reveal qualitatively different results depending on whether information is perceived with or without awareness. The logic underlying this alternative approach is based on the assumption that information perceived with awareness enables a perceiver to act intentionally on the world and to produce effects on the world (cf. Chalmers, 1996; Searle, 1992), whereas information perceived without awareness leads to more automatic reactions that cannot be controlled by the perceiver. Given this assumption, there should be numerous situations in which perceiving with and without awareness will lead to qualitatively different consequences, and by establishing such qualitative differences, it is possible to demonstrate that perception occurs in the absence of an awareness of perceiving.

A good example of the way contrasts between perception with and without awareness have been used to demonstrate perception without awareness comes from a study conducted by Debner and Jacoby (1994). In this study, the likelihood that words were perceived with or without awareness was controlled by varying the stimulus conditions. On each trial, a word was presented and masked, and the interval between the onset of each word and the onset of the mask was either relatively short (i.e. 50 ms) or somewhat longer (i.e. 150 ms). Immediately following the mask, the first three letters of the word were presented again and the participants were told to complete the word stem with the first word that came to mind *except* the word that had just been presented. For example, if the word presented on the trial was *frigid*, then immediately following the presentation of *frigid*, the letter stem *fri* was presented and the participants were instructed to use any word other than the word that had just been presented to complete the word stem. For example, the participants could complete the word stem with *fright*, *fringe*, *frites* or even *Friday* but not with *frigid*.

The general pattern of results found by Debner and Jacoby (1994) is shown at the top of Fig. 3. The figure shows that the participants had difficulty following the instructions when the words that preceded the word stems were presented for the short, 50 ms duration. Despite the explicit instructions not to complete the word stems with the presented words, these words were used to complete the stems much more often than they were used in the baseline condition (i.e. broken line in Fig. 3) in which each word stem was preceded by an unrelated word. However, as is also shown in Fig. 3, when the words were presented for the slightly longer, 150 ms duration, the participants used the presented words much less often to complete the stems than occurred in the baseline condition. Thus, the words presented before the word stems influenced the participants' completions in opposite ways, relative to the baseline condition, depending on whether they were presented for 50 or 150 ms. Given the assumption that perception with awareness enables a perceiver to control actions, whereas perception without awareness leads to more automatic reactions, these results suggest that the participants were generally aware of the words presented for 150 ms and generally unaware of the words presented for 50 ms. As such, the results provide additional evidence that perception can occur in the absence of awareness.

Qualitative differences in the consequences of perception have also been found

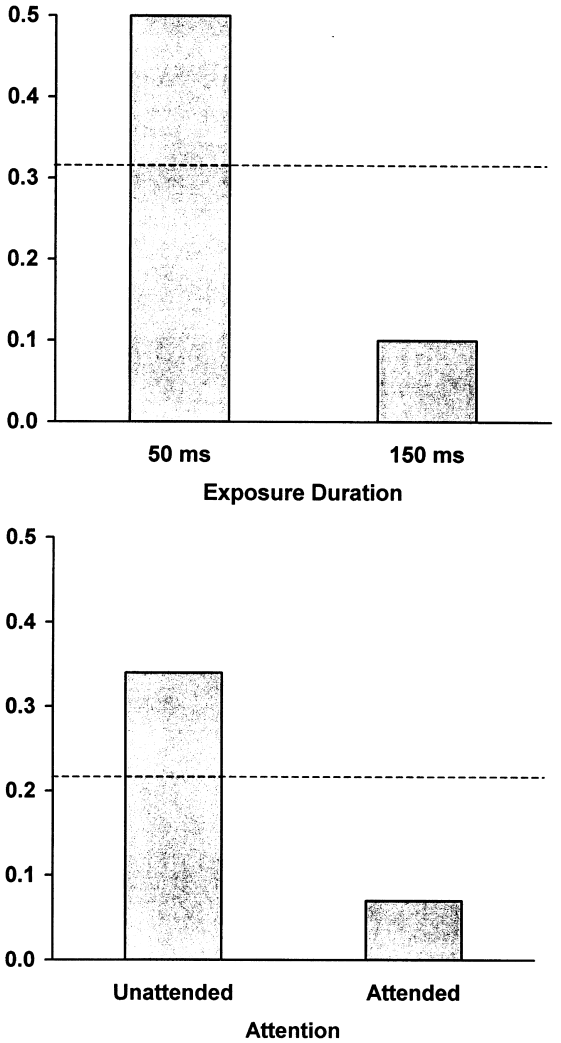

Fig. 3. Probability of NOT following exclusion instructions when awareness is varied via exposure duration (Debner & Jacoby, 1994) and when awareness is varied via attention (Smith & Merikle, 1999). The broken lines indicate baseline performance.

when awareness has been controlled by instructing participants on how to focus their attention. A good example comes from a recent series of studies conducted by Smith and Merikle (1999). In these studies, the stimulus displays were similar to the displays used by Mack and Rock (1998) on trial 3 in their studies of inattentional blindness (see Fig. 2). However, the general methodology differed from the methods used by Mack and Rock in two important ways. First, rather than presenting just one critical display to each participant, a total of 180 displays was presented. Second, the

task demands either emphasized the importance of focusing attention on the words in the displays or emphasized the importance of focussing attention on the crosses so that the words were unattended. The consequences of perceiving words with and without attention were assessed using a stem-completion task in conjunction with the same instructions used by Debner and Jacoby (1994). Thus, following each display, the first three letters of the word were presented and the participants were told to complete the word stem with the first word that came to mind *except* the word that had just been presented. The results are shown at the bottom of Fig. 3. What is immediately apparent when viewing Fig. 3 is that the general pattern of results was similar to the pattern of results reported by Debner and Jacoby (1994). Namely, relative to the baseline level of performance (i.e. broken line in Fig. 3), the attended and unattended words influenced performance in opposite ways. When the words were unattended, the participants had difficulty following the instructions not to use the words in the displays to complete the stems, whereas when the words were attended, the participants were able to exclude most of the words in the displays from their completions of the word stems. These qualitatively different effects of attended and unattended words suggest that the participants were generally unaware of the unattended words and generally aware of the attended words. Thus, these results provide yet another demonstration of perception in the absence of awareness.

Other studies have revealed additional qualitative differences in performance which are consistent with the basic assumption that stimulus information perceived with awareness enables a perceiver to use the perceived information to control actions, whereas stimulus information perceived without awareness leads to more automatic reactions. Awareness in these studies has been controlled either by varying the stimulus conditions (e.g. Jacoby & Whitehouse, 1989; Marcel, 1980; Merikle & Joordens, 1997a; Murphy & Zajonc, 1993) or by instructing observers on how to distribute their attention (e.g. Merikle & Joordens, 1997b). The consistent finding in these studies is that when the stimulus conditions are good and the critical stimuli are attended, observers generally use the perceived stimulus information to control their actions, but when the stimulus conditions are poor or the critical stimuli are outside the immediate focus of attention, observers generally fail to use the perceived information to control their actions. Taken together, the results of these studies, by showing that perception with and without awareness can lead to qualitatively different consequences, provide considerable additional evidence that stimulus information is perceived even when there is no awareness of perceiving.

4. Conscious experience and perception without awareness

Now that it is firmly established that the concept of perception without awareness is valid in the sense that it leads to verifiable predictions, an obvious next step is to examine the functions of perception without awareness. One question that can be asked is how does information that is perceived without awareness influence conscious experience? This question has received relatively little attention in experimental studies to date because the goal of the vast majority of studies has been

simply to demonstrate perception without awareness. However, from the limited evidence that is available, it appears that when a visual stimulus is perceived without awareness, it can influence or bias both which stimuli are subsequently perceived with awareness and how subsequent visual stimuli are consciously experienced. Thus, it appears that two important functions of perception without awareness are that it biases *what* is perceived with awareness and influences *how* stimuli perceived with awareness are consciously experienced.

An example of how stimuli perceived without awareness can influence or bias *what* stimuli are perceived with awareness comes from a study reported by McCormick (1997). In this study, a cue was briefly presented to the left or right of a central fixation cross and followed 500 ms later by a target letter (i.e. *X* or *O*). The task for the observers was to indicate as fast as possible on each trial whether the target was an *X* or an *O*. On 15% of trials, the cue and the target letter appeared on the same side of fixation, whereas on 85% of the trials, the cue and the target letter appeared on opposite sides of fixation. Given that the most likely location of each target letter was to the side of fixation opposite to the location of the cue, the observers were instructed that to optimize performance they should focus their attention to the side of fixation opposite to the cue. The results indicated that when observers were aware of the cues, they were faster at identifying a target letter when it appeared on the side of fixation opposite to the location of the cue than when it appeared on the same side of fixation as the cue. These results clearly show that the observers were able to use the cues to orient their attention to the side of fixation opposite to the location of the cue. However, when the observers were unaware of the cues, the results indicated that the observers were faster at identifying a target letter when it appeared on the same side of fixation as the cue than when it appeared on the opposite side of fixation. These results clearly show that the cues perceived without awareness attracted attention and biased the observers so that they were able to identify a target letter in a cued location more efficiently than a target letter in the opposite location. Thus, the cues that were perceived without awareness influenced what the observers perceived with awareness.

A recent study of how visual cues perceived with and without awareness attract the attention of patients with visual neglect provides another example of how stimuli perceived without awareness can bias what stimuli are subsequently perceived with awareness (Danziger, Kingstone, & Rafal, 1998). For present purposes, the important characteristic of patients with visual neglect is that they typically claim not to see stimuli presented in the visual field contralateral to their lesion whenever stimuli are presented simultaneously to both the left and right visual fields. Danziger et al. (1998) exploited this characteristic by simultaneously presenting one cue in the left visual field and another cue in the right visual field. These cues indicated the two possible locations of a subsequent target stimulus, and because the patients tested in the study had right parietal lesions, the patients neglected the cues presented in the left visual field. Presentation of the cues was always followed by the presentation of a single target stimulus (i.e. a white cross) at the location of one of the cues. The question that Danziger et al. (1998) asked was whether a cue presented to the neglected, left visual field would attract attention despite the fact that the patients

were unaware of the cue. The results showed that the patients responded faster to the white cross used as the target stimulus when it appeared in a cued location in the neglected, left visual field than when it appeared in an uncued location in the neglected visual field. These results are entirely consistent with the earlier findings reported by McCormick (1997). They suggest that attention was oriented or attracted to the location of the cues in the neglected field despite the fact that the patients were generally unaware of these cues. As such, the results provide further support for the idea that visual stimuli perceived without awareness can influence or bias *what* is perceived with awareness.

How a stimulus is consciously experienced can also be influenced by stimuli perceived without awareness. A good example of the way in which a stimuli perceived without awareness can influence how another stimulus is consciously experienced comes from a early study reported by Dunlap (1900). In this study, Dunlap showed that the Müller–Lyer illusion can be induced by stimuli that are "…of such a low intensity as to be imperceptible" (p. 435). The participants in this study were presented with stimuli such as those shown in Fig. 4 and asked to indicate which of the two line segments appeared longer. Not surprisingly, for lines such as the one shown in Fig. 4A, the participants showed no bias in judging either the left or right segments as being longer. However, when faint angular lines such as those shown in Fig. 4B were added to the line segments, the participants were more likely to judge the line segment with the angular lines going away from the line segment (i.e. the left line segment in Fig. 4B) as being longer. Given that the angular lines were presented at stimulus intensities which were below the participant's threshold for reporting awareness, Dunlap concluded that "…under certain conditions things of which we are not … conscious have their immediate effects on consciousness" (p. 436).

More recently, it has been demonstrated that the Müller–Lyer illusion can also be induced by unattended stimuli that are perceived without awareness. In one study, Moore and Egeth (1997) used an adaptation of the procedure developed by Mack and Rock (1998). On the first three trials of this study, two horizontal lines which differed slightly in length were presented against a background of random black and white dots, and the observers reported which line appeared to be longer. On the critical fourth trial, the two lines were equal in length and the background dots were organized so that they formed either inward or outward pointing angular lines at the ends of each line. The results showed that most observers experienced the Müller–Lyer illusion on the fourth trial and judged the line with the outward pointing

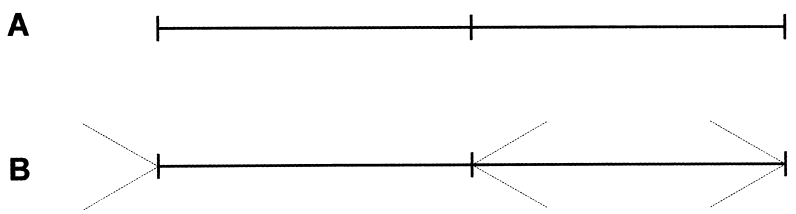

Fig. 4. Examples of the stimuli used by Dunlap (1900).

angular lines as being longer than the line with the inward pointing angular lines. However, the observers appeared to be completely unaware of the organized pattern in the background dots. When asked directly whether they noticed any pattern in the dots, no observer reported noticing a pattern, and when asked to make a forced-choice judgement among four possible patterns, performance did not differ from chance. These findings indicate that how the lines were consciously experienced was influenced by the organized pattern in the unattended background dots which was both unnoticed and perceived without any awareness of perceiving.

Another example of how unattended patterns can influence how stimuli are consciously experienced comes from a study in which the Müller–Lyer illusion was induced in patients with visual neglect by stimulus patterns in the neglected visual field (Mattingley, Bradshaw, & Bradshaw, 1995). These investigators first asked patients with left visuospatial neglect to bisect horizontal line segments. Not surprisingly, the patients bisected the lines with a bias toward the right such that the left portions of the bisected lines were longer than the right portions of the lines. Such findings indicate that the patients were unaware of at least some portion of the lines in the left visual field. To establish whether stimulus information in the neglected left visual field was perceived despite the fact that the patients seemed to be unaware of this information, Mattingley et al. (1995) added either inward or outward pointing angular lines at the left ends of the lines. The results indicated that when inward pointing lines were added, the patients tended to bisect the lines more to the left and that when outward pointing lines were added, the patients tended to bisect the lines more to the right. Thus, the way in which the patients bisected the lines was biased by the angular lines in the neglected left visual field. These findings are entirely consistent with the idea that the patients' conscious percepts of the lines, as indicated by the way in which they bisected the lines, were influenced by information in the neglected left visual field that they were unaware of perceiving. Taken together with the early results reported by Dunlap (1900) and the more recent findings reported by Moore and Egeth (1997), these findings provide considerable support for the idea that stimuli perceived without awareness influence *how* other stimuli are consciously experienced or perceived.

5. Concluding comments

After more than a century of research studies investigating perception without awareness, it is possible to conclude with considerable confidence that stimulus information can be perceived even when there is no awareness of perceiving. This conclusion is supported both by the results of studies demonstrating dissociations between measures of perception with awareness and measures sensitive to perception without awareness and by the results of studies showing that perception with and without awareness leads to qualitatively different consequences. In addition, the results of these research studies lead to the same conclusion whether awareness has been controlled by varying the stimulus conditions or by instructing observers on how to distribute their attention. Given these findings, the weight of the

evidence clearly shows that perception without awareness occurs in numerous situations and under a variety of conditions.

Some may argue that the findings are not convincing because many studies have been based on subjective measures of conscious experiences rather than on objective measures of forced-choice discriminations (e.g. Greenwald et al., 1996; Snodgrass, Shevrin, & Kopka, 1993). Such skepticism, however, is only valid if one makes the dubious assumption that objective measures of forced-choice discriminations provide a more reliable behavioral measure of the subjective conscious state that we call awareness than is provided by observers' reports or descriptions of their conscious mental states. We know of no evidence to support such an assumption. In fact, we suggest that objective measures of performance generally provide conservative indicators of awareness and that verbalizations of subjective conscious experiences generally provide a more direct and accurate indication of the presence or absence of an awareness of perceiving. As long as verbalizations are accepted as a measure of awareness, the only reasonable conclusion that can be reached on the basis of the accumulated evidence is that considerable stimulus information is perceived under conditions that do not lead to the subjective conscious experiences normally associated with perceiving.

Now that the concept of perception without awareness has been shown to have a solid empirical basis, an important direction for future research studies is to explore the ways in which stimulus information perceived without awareness influences conscious experience. The available evidence suggests that information perceived without awareness can influence conscious experience in at least two distinct ways. First, it can bias what stimuli are attended, and second, it can influence how attended stimuli are consciously experienced. In future studies, these and other possible functions of information perceived without awareness need to be further explored. In addition, it will be important to evaluate how any functional differences that are documented may be related to or mediated by different neural pathways. For example, Posner and Rothbart (1992) have made a distinction between a posterior attention network, which mediates the orientation of attention, and an anterior attention network, which mediates consciousness awareness of attended objects. Given this distinction, stimuli perceived without awareness may influence *what* is attended via the posterior attention network and influence *how* attended stimuli are consciously experienced via the anterior attention network. With the tools that are now available for assessing perception without awareness, it should be possible to evaluate the role that different neural pathways play in mediating functional differences in the ways that information perceived without awareness influences or biases how other stimuli are consciously perceived and experienced.

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