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Review

Functional consequences of perceiving facial expressions of emotion without awareness

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Abstract

A substantial body of research has established that even when we are not consciously aware of the faces of others we are nevertheless sensitive to, and impacted by their facial expression. In this paper, we consider this body of research from a new perspective by examining the *functions* of unconscious perception revealed by these studies. A consideration of the literature from this perspective highlights that existing research methods are limited when it comes to revealing possible functions of unconscious perception. The critical shortcoming is that in all of the methods, the perceived facial expression remains outside of awareness. This is a problem because there are good reasons to believe that one important function of unconsciously perceived negative faces is to attract attention so that they are consciously perceived; such conscious perception, however, is never allowed with existing methodologies. We discuss recent studies of emotional face perception under conditions of visual search that address this issue directly. Further, we suggest that methodologies that do not examine cognitive processes as they occur in more natural settings may result in fundamental misunderstandings of human cognition.

Keywords: Face perception; Unconscious perception; Perception without awareness; Ecological validity; Facial expression; visual attention

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1. Introduction

At any given moment, the human perceptual system is able to process a vast amount of information from the environment. However, given the capacity limits of conscious experience (Miller, 1956), we do not notice (Bowers, 1984) or have a conscious experience of all the information that is processed by the perceptual system. Rather, we can perceive information without an accompanying awareness of the information that was perceived, and without awareness of the fact that such perception has occurred (Dixon, 1971, 1981; Merikle & Daneman, 2000; Merikle, Smilek, & Eastwood, 2001). Considerable research has investigated perception without awareness; and, in so doing, has established that information perceived without awareness can significantly influence behaviour, physiology, and subsequent conscious experiences (see Merikle et al., 2001 for a review). Such observations challenge the conventional view that the influence of environmental information is necessarily mediated by a conscious experience of that information.

Earlier, investigators such as Arne Öhman (e.g., Öhman, Anders, & Lundqvist, 2000) have suggested that, given the *existence* of unconscious perception has been extensively demonstrated, it is now time to shift the focus of inquiry to gaining a better understanding of the *functions* of unconscious perception (see also Merikle et al., 2001). One critical step in this new direction is to review existing studies of unconscious perception (much of which was conducted to find evidence for the existence of unconscious perception) in terms of what they can tell us about the functions of unconscious perception. After reviewing past studies in this manner, another important step is to consider how the existing methodologies determine, and limit, what functions of unconscious perception can be revealed.

In this paper, we seek to move in this new direction by taking a function-oriented perspective on one area of unconscious perception research—namely, the unconscious perception of affective stimuli. We choose to focus our discussion on affective stimuli in general, and affective faces in particular, for several reasons. First, affective stimuli are a basic and important aspect of our environment. For example, with respect to our survival and well-being, some aspects of our environment are "good or bad" (Clore, Schwartz, & Conway, 1994) and, therefore, need to be approached or avoided (Gray, 1987). Thus, the unconscious perception of affect is likely to have numerous important functions for an individual's successful interaction with their environment. A second reason for focusing on the function of unconscious perception of affective stimuli is that there is a large body of research showing that affective information can be perceived quickly, efficiently (Junghöfer, Bradley, Elbert, & Lang, 2001; Zajonc, 1980) and without awareness (see Öhman, 1999).

Our re-evaluation of the existing literature in terms of the functions of unconscious perception requires that we begin by describing the empirical *methodologies* that have been used historically to establish that affective stimuli can be perceived without awareness. Because our aim is to describe existing methodologies, we do not provide an exhaustive review of all the literature concerning unconscious perception of emotional stimuli and all of the debates that have emerged in that literature. Instead, we focus on studies that clearly illustrate the methodologies used to study unconscious perception. We then narrow our consideration of affective stimuli and focus specifically on unconscious perception of facial expression and outline what the established methodologies have revealed about the *functions* of perceiving emotionally expressive faces without awareness. Our goal in this regard is to elucidate what the existing literature tells us about the functions of

unconscious perception of emotionally expressive faces—rather than attempting to demonstrate that the functions of perceiving facial expression without awareness are necessarily unique.

Based on our consideration of existing demonstrations of unconscious perception of emotionally expressive faces, we suggest that the commonly used methods for demonstrating unconscious perception fail to capture important functions of such perception. We suggest that new empirical methodologies may be required in order to generate a more complete, accurate understanding of the functions of perceiving facial expression without awareness. Finally, we suggest that experimental methodologies that do not examine cognitive processes as they occur in more natural settings may result in fundamental misunderstandings of human cognition.

2. Methodologies for studying unconscious perception of emotion

Historically, three different types of experiments have been used to establish the presence of unconscious perception of affective stimuli. The first method of *demonstrating different recognition thresholds* for emotionally laden words fell out of favour relatively quickly and is rarely employed today. In contrast, the logic of showing a *dissociation between conscious and unconscious measures of perception* or showing *qualitatively different consequences of perception with or without awareness* have proved to be more compelling and are often used today.

2.1. Recognition thresholds

Many early empirical investigations of the question whether or not affective information can be perceived without awareness focused on the notion of 'perceptual defense' (see Brown, 1961; Kragh, 1960 for a review); namely, the idea that conscious recognition thresholds for stimuli vary as a function of the emotional meaning of the stimuli to be recognized (Bruner & Postman, 1949; Postman, Bruner, & McGinnies, 1948; McGinnies, 1949). Specifically, in these studies it was found that longer stimulus durations were required for observers to consciously recognize emotionally laden "taboo" words compared to more neutral words. Modulation of the information reaching awareness would require observers to be able to discriminate between emotional and non-emotional information prior to conscious awareness in order to selectively alter conscious recognition thresholds. Therefore, the presence of a 'perceptual defense' was taken as evidence for the claim that emotional information can be perceived without awareness. However, the original concept of 'perceptual defense' was brought into question by critiques of the empirical evidence on which it was based (see Bootzin & Natsoulas, 1965; Erdelyi, 1974). Perhaps the most devastating critique arose from considering lowered recognition thresholds for taboo words to result from a response bias in which participants were hesitant to report emotionally laden information. Based on these early studies of perceptual defense, therefore, it was unclear if in fact emotional information could be perceived without awareness.

2.2. Dissociation between measures

The claim that emotional information can be perceived without awareness was given stronger support from other studies based on different methodologies. Most commonly, researchers

attempted to demonstrate dissociation between two measures of perception (Goldiamond, 1958). In such an approach, one measure is assumed to assess the presence or absence of a conscious experience of stimulus information, while a second measure is assumed to assess whether or not an observer is sensitive to, or has "taken in," stimulus information. Therefore, if the second measure indicates that observers have indeed been influenced by stimulus information while the first measure indicates that observers have no awareness of the critical stimulus information, then it is concluded that perception without awareness has occurred (see Marcel, 1983; for an example of this approach used with non-affective stimuli).

An early experiment by Smith, Spence, and Klein (1959) serves as an example of how dissociation between two measures can be used to demonstrate the presence of unconscious perception of emotion. They found that tachistoscopically presented emotional words, presented below the threshold for awareness, influenced the judgment of a consciously perceived face. In the first session of their experiment, they determined the minimal exposure duration at which each individual participant consciously detected the presence of a briefly presented word. Then, in the second session, participants were shown a neutral, expressionless face and told that small and subtle changes would occur in the expression on the face and that they were to detect these changes and report them to the experimenter. The experimenter did not actually change the facial expression but rather presented the word "happy" for a group of trials and the word "angry" for another group of trials very briefly below each participant's previously determined threshold for awareness. Subjectively, participants reported seeing a constant presentation of the face interrupted by brief flickers. The experimental results, however, indicated that participants judged the face to be more positive when preceded by the word "happy" than when preceded by the word "angry." This second measure, the judgment of facial expression, revealed that participants perceived the emotional words even though the measure of conscious perception (the threshold for detecting the presence of words) indicated that participants had no conscious experience of perceiving the emotional words.

In other early experiments, researchers employed a variety of measures thought to be sensitive to the perception of emotional information without awareness. For example, it was shown that emotional information contained in displays of unconsciously perceived words and pictures can: (1) determine the threshold at which other, neutral stimuli are consciously detected (Dixon, 1958; Hardy & Legge, 1968), (2) influence the evaluation of other stimuli, such as a cartoon character (Eagle, 1959) and responses to Thematic Apperception Test cards (Goldstein & Barthol, 1960), and (3) alter heart rate as well as other physiological measures such as the electroencephalogram (Dixon & Lear, 1963, 1964). It was claimed that all of these effects occurred even when participants had no conscious experience of perceiving the emotional information.

Recent investigations of unconscious perception of emotion continue to rely heavily on the same basic method of demonstrating dissociation between a measure of conscious perception and a measure of unconscious perception. However a notable change over the past several decades has been a shift away from psychodynamic conceptualizations of unconscious perception of emotion (Dixon, 1971) towards conceptualizations informed by evolutionary (Öhman, 1999; Plutchik, 1994) and neurobiological (LeDoux, 1996) approaches to the study of emotion and consciousness. An example of a more recent approach to the study of the unconscious perception of emotion using dissociation between measures is the work of Öhman and Soares (1993). These investigators conducted a conditioning study and concluded that physiological responses to

conditioned fear stimuli can be elicited "after merely an automatic, non-conscious analysis of the stimuli" (p. 128). Their experiment consisted of a conditioning and an extinction phase. During the conditioning phase, participants consciously perceived "fear-relevant" (snakes and spiders) or "fear-irrelevant" (flowers and mushrooms) stimuli that were paired with either an uncomfortable electrical shock or no aversive stimulus. In the subsequent extinction phase, the conditioned and unconditioned stimuli were presented briefly for 30 ms and masked. When the fear relevant and irrelevant stimuli were presented under these conditions participants were not able to verbally guess above chance which category (snake, spider, flower, or mushroom) the masked stimuli belonged to. Therefore, Öhman and Soares claimed this measure of conscious perception indicated that participants were not consciously aware of the stimuli. However, even though participants did not consciously perceive the conditioned stimuli, during the extinction phase of the experiment differential skin conductance responses (a measure of unconscious perception) were elicited by the unconsciously perceived fear-relevant stimuli that had been paired with a shock. In contrast, unconscious perception of fear-irrelevant conditioned stimuli, such as flowers and mushrooms, was not evident during the extinction phase. Öhman and Soares' work illustrates the most common approach that is currently used to establish unconscious perception of emotion; namely, demonstrating dissociations between measures of conscious and unconscious perception.

Although demonstrating dissociation between a measure of conscious perception and a measure of unconscious perception continues to be a very common methodology used in studies of unconscious perception of emotion, significant criticisms have been raised regarding the validity of such an approach (see Merikle et al., 2001; Merikle & Joordens, 1997a; Merikle & Reingold, 1998; Öhman, 1999). Since early investigations into unconscious perception, considerable debate has taken place regarding what constitutes a satisfactory measure of an observer's conscious experience (Merikle, 1992). In particular, investigators have debated whether observers' conscious experience should be measured by 'subjective' self-reports, that is, observers' report of whether or not they consciously perceived the stimuli, or, by 'objective' performance on a task for which conscious perception is assumed to be both necessary and sufficient for successful completion (see Bowers, 1984; Merikle et al., 2001).

In addition, considerable debate has taken place as to whether or not the basic assumptions underlying dissociation strategies can be satisfactorily achieved. For example, the dissociation strategy is predicated on the assumption that the measure of conscious perception has exhaustively assessed an observer's conscious experience. However, a measure may fail to indicate that an observer was aware of stimuli simply because the measure lacks statistical power or is not sensitive to all of an observer's conscious experience. Furthermore, the measure of conscious perception must assess the same aspect or dimension of the stimulus that is assessed by the measure of unconscious perception. For instance, if the measure of unconscious perception is sensitive to the affective valence of a stimulus then the measure of conscious perception must also assess awareness of the valence of the stimulus, rather than some other stimulus dimension. Second, in order for the dissociation procedure to be successful it is important that the measure of conscious perception is just that—an exclusive measure of conscious influences. If, for example, the measure of conscious perception is actually influenced by unconscious perception then an investigator may, in an overly conservative manner, fail to find evidence for an effect of unconscious perception because the dissociation method would inappropriately attribute an observer's ability to discriminate among stimuli to conscious perception. In light of problems with the dissociation strategy

and continued disagreement regarding its application, researchers have turned to different methodologies.

2.3. Qualitative differences

Another approach to establishing the presence of unconscious perception of emotion is to demonstrate that observers respond in a qualitatively different manner to emotional information that is perceived with awareness, compared to without awareness (Cheesman & Merikle, 1986; Dixon, 1971; Merikle et al., 2001; Merikle & Joordens, 1997a). In general, this approach is predicated on the assumption that information perceived without awareness will result in more automatic, less deliberate responses than the same information perceived with awareness. Therefore, it is often possible to predict qualitatively different response patterns depending upon whether observers perceive the emotional information with awareness or without awareness. For example, under certain situations an inverse relation between awareness and the impact of a stimulus is predicted; that is, a larger effect is expected when a stimulus is perceived without awareness compared to when it is perceived with awareness because when a stimulus is perceived with awareness its potential influence can be excluded (e.g., Jacoby & Whitehouse, 1989) or otherwise avoided or resisted.

The "exclusion task" developed by Jacoby and colleagues (e.g., Debner & Jacoby, 1994; Jacoby, 1991; Jacoby & Whitehouse, 1989) is a historically and theoretically important example of demonstrating that observers respond in a qualitatively different manner to conscious and unconsciously perceived information. In the "exclusion task" the influence of consciously and unconsciously perceived information is placed in opposition to one another. For example Debner and Jacoby (1994) asked participants to complete a three letter word stem (e.g., spi__) with the first five letter word that came to mind (e.g., spice or spike, etc.). After collecting a baseline measure of how frequently various words were used to complete the stems, participants were shown a potentially biasing prime word (e.g., spice) immediately before the three letter word stems. In one condition the potentially biasing prime word was presented for 50 ms. and then masked. In another condition the potentially biasing prime word was presented for 500 ms and then masked. In both conditions participants were instructed to complete the three letter word stem with any word that came to mind, *except* the word that had just been presented. Debner and Jacoby observed that participants were able to follow the exclusion instructions when the prime word was presented for 500 ms (i.e., they completed the word stem below baseline levels for the prime word); whereas, they failed to follow the exclusion instructions when the prime word was presented for 50 ms (i.e., they completed the word stem above baseline levels for the prime word). This pattern of results suggests that the prime word was perceived when it was presented for 50 ms and when it was presented for 500 ms; however, relative to baseline, it had an opposite influence in these two conditions. Based on the assumption that conscious perception is necessary and sufficient for deliberate exclusion (i.e., following instructions) then successful exclusion is taken as evidence for conscious perception; whereas, unsuccessful exclusion (that is significantly above baseline stem completion) is taken as evidence for unconscious perception. Jacoby (e.g., 1991) has also used the exclusion task as part of a more complex 'process-dissociation procedure' which, he argues, can estimate separate conscious and unconscious influences on behaviour. However, some debate exists as to whether or not it is more fruitful to

think about conscious and unconscious perception giving rise to separate, independent influences (e.g., Jacoby, Toth, & Yonelineas, 1993; Jacoby, Toth, Yonelinas, & Debner, 1994) or relatively more or less influence (e.g., Joordens & Merikle, 1993; Merikle & Joordens, 1997b; Merikle, Joordens, & Stolz, 1995).

Research on terror management theory (Solomon, Greenberg, & Pyszczynski, 1991) provides a good example of how qualitatively different consequences of perceiving *emotional information* with and without awareness can be used to establish unconscious perception of emotion. Terror management theory postulates that we instinctively fear death, and that we attempt to cope with an awareness of the fact that we will inevitability die by clinging to our cultural belief system (cultural world-view). Therefore, reminding people of their mortality will increase their faith and adherence to their cultural world-view and lead to more negative judgments of others who threaten, or do not endorse their cultural world-view. Critically, however, subtle and unconscious reminders of mortality are thought to be more effective at bolstering one's world-view than conscious reminders of death. Arndt, Greenberg, Pyszczynski, and Solomon (1997), for example, found that participants showed a pro-United States bias when evaluating essays regarding cultural values, if they were previously shown the word "dead." However, this bias was only evident if the word "dead" was masked and presented so briefly that participants had no awareness of perceiving it. In contrast, if participants perceived the word "dead" with awareness, no pro-United States bias was observed in the evaluation of the essays.

2.4. Summary

In summary, numerous studies have sought to demonstrate that emotional information can be perceived without awareness. These studies have relied exclusively on three methodologies, which involve demonstrating: (a) different recognition thresholds for emotionally laden words, (b) a dissociation between conscious and unconscious measures of perception, and, (c) qualitatively different consequences of perception with or without awareness.

In some sense, the conclusion that emotional stimuli can be perceived without awareness is not entirely surprising given the importance of emotional information for human survival. Indeed, it seems clear that having a capability of perceiving affective stimuli without awareness would be extremely functional. What remains unclear, however, is what specific function(s) does such unconscious perception serve in the human context? And, are the existing methodologies for studying perception without awareness adequate for demonstrating critical functions of unconscious perception of emotional content? It is to these functional considerations that we turn next.

3. Functions of unconscious perception of facial expression

In considering the functions of unconscious perception, we will narrow our focus to a commonly studied affective stimulus—emotional facial expression. Based on a consideration of these studies, we ultimately suggest that while the existing methodologies for studying unconscious perception reveal important functions of unconscious perception of facial emotion, *the methodol-*

ogies typically employed are limited in terms of the possible functions that they could potentially uncover.

Facial expression is one type of affective stimulus that has received special attention in studies of unconscious perception. Faces are a critically important source of social information and it appears as though we are biologically prepared to perceive and respond to faces in a unique manner (Ekman, 1993). A considerable amount of research has established that the visual system is highly efficient at perceiving facial expression (e.g., Bruce, Desimone, & Gross, 1981; Desimone, 1991; Farah, Wilson, Drain, & Tanaka, 1998; Gorea & Julesz, 1990; Hasselmo, Rolls, & Baylis, 1989; Hochberg & Galper, 1967; Homa, Haver, & Schwartz, 1976; Purcell & Stewart, 1988; Schwartz, Izard, & Ansul, 1985; Tanaka & Farah, 1993). It has also been shown that infants demonstrate an early proficiency at discriminating faces from non-face stimuli (e.g., Öhman & Dimberg, 1978; Meltzoff & Moore, 1977; Sackett, 1966) and at discriminating different emotional expressions (Younge-Browne, Rosenfeld, & Horowitz, 1977). Furthermore, it has been shown that the affective information contained in facial expression is perceived involuntarily (Eastwood, Smilek, & Merikle, 2003) and is able to constrict the focus of attention (Fenske & Eastwood, 2003). Considering the critical social relevance of facial expression of emotion, it is perhaps not surprising that the emotion displayed in facial expression can be perceived even when observers have no conscious experience of perceiving facial expressions.[1] Such unconscious perception of facial expression has been shown to have several *important functions.* These functions include: eliciting emotional responses in the observer; influencing the conscious experience of other stimuli; and influencing face-to-face communication.

3.1. Eliciting emotional responses

When confronted by a fear-inducing stimulus, such as an angry facial expression, observers show emotional responses that consist of distinct patterns of physiological arousal. These patterns of physiological arousal include a large skin conductance response, hormone changes, and sympathetic nervous system responses involving the amygdala and hypothalamus (Globisch, Hamm, Esteves, & Öhman, 1999; Hamm, Cuthbert, Globisch, & Vaitl, 1997; Öhman, 1999). This emotional response can even be elicited by facial expressions that are perceived without awareness. Specifically, research has demonstrated that unconsciously perceived angry facial expressions alter amygdala activity (Morris, Öhman, & Dolan, 1998, 1999), levels of stress hormones (van Honk et al., 2000), and skin conductance (Dimberg & Öhman, 1996; Esteves, Dimberg, & Öhman, 1994; Öhman, 1986). Consistent with the unconscious perception of other threatening stimuli, like spiders and snakes (e.g., Öhman & Soares, 1993, 1994), it appears that a physiological response to a fear-inducing facial expression is initiated before we have a conscious experience of what it is that we are responding to. This rapid physiological response to an unconsciously perceived facial expression prepares us to react in an adaptive manner to the presence of a threatening individual.

[1] As mentioned earlier, we are not arguing that faces are unique in terms of their ability to be perceived without awareness; nor do we wish to argue that the functions of perceiving faces without awareness are unique. Rather, in the present manuscript, we attempt to: (1) summarize what existing findings tell us about the functions of perceiving emotionally expressive faces without awareness and (2) highlight critical limitations in current methodologies.

Many sympathetic responses to threat are mediated by the amygdala (Davidson & Irwin, 1999); therefore, it is perhaps not surprising that unconsciously perceived facial expressions have been shown to alter amygdala activity. Morris et al. (1998, 1999) found that overall; the amygdala was more active when observers were presented with an aversively conditioned angry face than when they were presented with a non-conditioned angry face. Critically, however, they also found that a significant neural response was evident in the right amygdala even when the conditioned angry faces were masked and therefore not consciously perceived. Whalen et al. (1998) also examined whether or not the amygdala is activated in response to emotionally expressive faces, even when observers are unaware that such stimuli have been presented. These investigators used fMRI and found significant increases in activation in the amygdala in response to fearful faces and significant decreases in activation in the amygdala in response to happy faces when the facial expressions were perceived without awareness. This finding that amygdala activity is sensitive to unconsciously perceived facial expressions is consistent with LeDoux's (1996) claim that there is a direct neural pathway from the sensory thalamus to the amygdala, which is able to support rapid and defensive responses to potentially dangerous stimuli, even before conscious identification and evaluation of the stimuli.

Unconsciously perceived angry faces have also been shown to alter levels of stress hormones. In a series of studies, van Honk and his colleagues have explored the relations between salivary hormone levels, trait anxiety, trait anger, and the unconscious perception of facial expression. They have found evidence indicating that individuals high in baseline levels of cortisol (van Honk et al., 1998) and high on measures of trait anger (van Honk, Tuiten, de Haan, van den Hout, & Stam, 2001) are able to distinguish angry and neutral faces that are perceived without awareness. van Honk et al. (2000) also found evidence which indirectly suggests that perceiving angry faces without awareness leads to increases in salivary testosterone and cortisol levels from pre-exposure baseline levels (van Honk et al., 2000). This latter finding has the potential to extend previous observations showing a temporary increase in testosterone and cortisol levels when observers face social threat (Gladue, Boechler, & McCaul, 1989) by suggesting that they may not need to be aware of the source of social threat.

Research has also established that a threatening face perceived without awareness can elicit increased skin conductance, which is another component of the fear response. For example, observers show an increased skin conductance (Dimberg & Öhman, 1996; Öhman, 1986; Esteves et al., 1994) in response to an unconsciously perceived angry face that has previously been paired with an unconditioned aversive stimulus. Furthermore, Öhman and his colleagues (Esteves et al., 1994) have demonstrated that associative learning can occur with faces expressing anger, even when observers remain unaware of the angry faces that are paired with an unconditioned aversive stimulus. In response to subsequent presentations of these conditioned angry faces, observers show an increased skin conductance. Taken together, these studies suggest that conditioned skin conductance responses can be both elicited by, and also associated with an unconscious perceived angry face.

In summary, a substantial amount of research has established that unconsciously perceived facial expression elicits emotional responses that include various forms of physiological arousal. When a negative or threatening facial expression is perceived without awareness, observers show a pattern of physiological arousal that includes a large skin conductance response, hormone changes, and alteration in amygdala activity. This rapid physiological response to an uncon-

sciously perceived facial expression is likely adaptive because it prepares us to react in an effective manner to the presence of a threatening individual.

3.2. Influencing conscious experience

Another important consequence of perceiving a facial expression without awareness is that unconsciously perceived facial expression can influence subsequent conscious experience. For example, research conducted with both healthy observers (e.g., Edwards, 1990; Kragh, 1960, 1962; Murphy & Zajonc, 1993; Niedenthal, 1990) as well as neurological patients (de Gelder, Pourtois, van Raamsdonk, Vroomen, & Weiskrantz, 2001) has demonstrated that unconsciously perceived facial expression can bias how other stimuli are consciously experienced. Furthermore, facial expressions that are perceived without awareness have also been shown to bias observers' self-evaluation (Baldwin, Carrell, & Lopez, 1990).

Experimental studies with normal observers have shown that unconsciously perceived facial expressions can influence how other stimuli are consciously experienced. For example, in an experiment reported by Niedenthal (1990), observers were briefly (i.e., 2 ms) presented with a face displaying joy, disgust or a neutral emotion followed by a neutral cartoon character that they were required to evaluate. Although observers had no conscious experience of the facial expressions and were not able to identify the expressions when tested with a forced choice task, evaluations of the cartoon characters were biased by the affective tone of the facial expressions. That is, observers formed affective judgments of the cartoon characters that were consistent with the emotional expression of the unconsciously perceived faces. Zajonc and his colleagues (Edwards, 1990; Murphy & Zajonc, 1993; Murphy, Monahan, & Zajonc, 1995; Winkielman, Zajonc, & Schwarz, 1997) have also used a priming procedure to demonstrate that unconsciously perceived faces expressing happiness and anger bias the evaluation of a neutral Chinese ideograph (see also Kemps, Erauw, & Vandierendonck, 1996; Raccuglia & Phaf, 1997).

Experiments with neurological patients have also demonstrated that facial expression can be perceived without awareness (de Gelder, Vroomen, Pourtois, & Weiskrantz, 1999) and influence how other stimuli are consciously experienced (de Gelder et al., 2001). For example, de Gelder et al. (2001) report a study with GY, a blindsight patient who has sustained damage to the left striate and extra-striate cortex, and therefore is unaware of stimuli presented in his right visual field. GY's reaction time to facial expressions presented in his intact visual field was influenced by the emotional expression of faces that were presented in his blind visual field even though he was unaware of the facial expressions in his blind visual field. GY was able to identify the emotional expression of faces in his intact visual field more quickly when a congruent emotional expression was simultaneously presented in his blind visual field. This finding suggests that the emotional expression of a face that was perceived without awareness, facilitated or interfered with the identification of the emotion displayed by another, consciously perceived face.

In addition to influencing the experience of external stimuli, unconsciously perceived facial expressions may also bias observers' self-evaluations. For example, Baldwin et al. (1990) demonstrated that graduate students' self-evaluations were lower after they unconsciously perceived their department chair expressing a disapproving scowl compared to when they unconsciously perceived a postdoctoral fellow expressing an approving smile. Participants first completed what was described as a reaction time task in which they were required to press a key as quickly as

possible when an orange patch appeared on a screen. Unbeknownst to the participants, a picture of a significant department figure displaying either an approving or disapproving facial expression was very briefly presented before the orange patch. The face was presented briefly and masked by the patch of orange such that participants had no conscious experience of the approving and disapproving face. After completing the reaction time task, participants were then required to evaluate their research ideas. The findings indicated that participants evaluated their research ideas more negatively after unconsciously perceiving a chairperson's disapproving face (Baldwin et al., 1990).

In summary, studies using healthy observers and studies using neurological patients support the idea that an unconsciously perceived facial expression can influence how other stimuli are consciously experienced. Furthermore, it appears as if facial expressions that are perceived without awareness can bias observers' self-evaluations. Taken together, the available evidence provides support for the general claim that unconsciously perceived facial expressions are able to influence subsequent conscious experiences.

3.3. Social interactions

It has been demonstrated that perceiving facial expression without awareness can play a role in social interactions. For example, researchers have demonstrated how facial expression perceived without awareness might influence experience in everyday social situations outside the laboratory (de Gelder, Pourtois, Vroomen, & Bachoud-Lévi, 2000). Furthermore, it appears that unconsciously perceived facial expression can modulate face-to-face communication (Dimberg, Thunberg, & Elmehed, 2000).

de Gelder et al. (2000) describe the case of AD, a prosopagnosic patient. AD cannot recognize facial expression in isolation and yet a concurrently presented happy or fearful face was shown to influence her judgment of the affective tone of a voice. Therefore, for AD, an unconsciously perceived facial expression exerts a "cross-modal" bias on the conscious experience of voice expression. de Gelder and Vroomen (2000) have also found that normal observers show an involuntary influence from facial expression on the judgment of the emotional tone of a voice. In everyday social contexts, then, our evaluation of an individual's tone of voice may be influenced by the speaker's facial expression, even when we are unaware of facial expression. Such an influence of unconsciously perceived facial expression on the conscious experience of voice quality might prove to be an example of how social interactions can be subtly influenced by unconscious perception of facial expression.

Another example of how facial expression perceived without awareness plays a role in social interactions is found in the micro-components of face-to-face exchanges between people. Dimberg et al. (2000) have demonstrated that facial muscle activity in observers mirrors the emotional expression of faces that are perceived without awareness. In their study, observers were prevented from consciously perceiving happy, angry, and neutral facial expressions by a backward-masking procedure. Yet, despite being unaware of the facial expressions, observers showed larger zygomatic major muscle activity and smaller corrugator supercillii activity in response to happy compared to angry faces. Thus, they conclude that facial responses to the facial expression of others are "controlled by rapidly operating affect programs that can be triggered independently of conscious cognitive processes" (p. 88). These results suggest that facial expressions

perceived without awareness can evoke physiological responses that have important social consequences. Dimberg et al. note that these facial responses to the expressions of others might represent either a mimicking of external behaviour or a change in observers' underlying emotional state. In either case, such implicit facial dialogue likely forms a foundation for face-to-face communication.

Research has begun to explore some of the functions that unconsciously perceived facial expression might play in everyday social contexts. To date, it has been demonstrated that facial expression perceived without awareness can bias the experience of voice quality and can also elicit "mirroring" facial responses in an observer.

3.4. Summary and limitations

As is clear from the foregoing discussion, the common methods for studying unconscious perception of emotionally expressive faces show that such perception serves several distinct and interesting functions. Unconscious perception of emotional faces serves to: (a) elicit emotional responses in the observer, (b) influence how other stimuli are consciously perceived, and (c) influence social communication.

Yet a consideration of the methods used also suggests they are limited in their ability to reveal the possible functions of unconscious perception of facial expression. Specifically, to date, the experimental methods used to explore unconscious perception of facial expression *have all required that the perceived facial expression remains outside of awareness*. That is, the goal has been to create laboratory situations where observers *are never aware* of the facial expressions. Indeed, the very logic of the experimental designs hinge on the fact that observers never become aware of the faces. While this approach has facilitated attempts to establish the existence of unconscious perception, it necessarily imposes limits on our ability to understand the functions of unconscious perception of facial expression in more natural settings; because in more natural settings one might think that an unconsciously perceived facial expression would attract the attention of an observer, *resulting in the observer efficiently becoming aware of the affective face*. Therefore, while the stimuli in these studies often have good ecological validity, the *methods* are lacking ecological validity in a critical way.

4. A new function: Unconsciously perceived affective faces grab awareness

Ideas from the field of ethology provide a clear rationale for why the emotion expressed by an unconsciously perceived negative face might serve to attract attention so that it is consciously perceived. Namely, conscious perception of facial expression is important because many of the behaviours that one must make in response to perceived facial expression require conscious mediation (Öhman, 1986). For example, facial expression is inextricably involved in displays of dominance and submission, or what has been termed "ritual agonistic behaviour" (Trower & Gilbert, 1989). Ritualized agonistic behaviour, such as the dominant expression of anger with a fixated staring gaze and the corresponding submissive expression of fear with averted eye gaze, serves to establish and maintain dominance hierarchies (Hinde, 1974; Mazur, 1985) without actual physical conflict. Such dominance hierarchies are believed

to be a critical component of group living because they secure social order and regulate social exchange.

When confronted with a dominant individual, however, one cannot escape by simply fleeing, as one might when confronted by a predator threat. Instead, one must determine their relative social status and, if appropriate, signal defeat and submissiveness. Typically such submissive gestures include gaze aversion and "an uncomfortable, appeasing smile" (Öhman, 1986, p. 129). Therefore, unlike simple and automatic "fight" or "flight" physiological responses, submissive gestures require a more complex and subtle behavioural repertoire (Öhman, 1986). Given that subtle and complex social responses are often required in response to perceiving negative facial expression, it would be advantageous for attention to be guided to an unconsciously perceived negative face so that observers become aware of the face and thus are able to engage in the conscious processing that is necessary to make adaptive responses.

However, this possible mechanism cannot be evaluated with previously used experimental methodologies. To evaluate the possibility that unconscious perception of facial expression results in an observer's focal attention being attracted to the face, a methodology is needed in which the ultimate result of perception is awareness—while still providing some indication of a pre-awareness sensitivity to facial expression. One task that provides precisely these conditions, though it is not often used to study unconscious perception, is the 'visual search task' (e.g., Eastwood et al., in press). When participants are required to search through a varying number of distractors to find emotionally expressive faces, it is possible to plot a function that displays the increasing time required to find each affective face as the number of distractors increases. These search functions provide an indication of the efficiency of search for a face in a given distractor context. Critically, when the distractor context is held constant (i.e., faces with neutral expressions) and participants do not know whether to expect a positive or negative target face, a comparison of the slopes of the search functions for the positive and negative faces can indicate whether positive and negative faces differ in their ability to attract attention and compete for awareness (see Duncan & Humphreys, 1989; Wolfe, 1994). A comparison of the respective search slopes is critical because any difference in the drawing power of different affective faces becomes more evident as set size increases because each additional distractor has a relatively smaller impact on overall search times for the face with the stronger drawing power. Therefore, if the search slopes differ for positive and negative faces it would indicate that the emotional expression associated with the shallower slope is the expression that observers became aware of more rapidly. In this manner, the visual search task is capable of assessing whether observers have a bias to preferentially process and become aware of particular types of facial expressions.

To date, applications of visual search methodology to the study of face perception have not led to clear, consistent conclusions (e.g., Fox et al., 2000; Hampton, Purcell, Bersine, Hansen, & Hansen, 1989; Hansen & Hansen, 1988; Nothdurft, 1993; Öhman, Lundqvist, & Esteves, 2001; Purcell, Stewart, & Skov, 1996; White, 1995). We argue that this lack of clarity is the result of methodological complications associated with applying the visual search task to the question: "Can emotionally expressive faces be perceived without awareness and bias the deployment of attention?"

One critical methodological issue is that many studies have confounded variations in the emotion expressed by the target face with variations in the emotion expressed by faces in the distractor context. For example, Hansen and Hansen (1988) found that the slope of the search function for

locating a target face expressing anger presented among distractor faces expressing happiness was shallower than the slope of the search function for locating a target face expressing happiness presented among distractor faces expressing anger. Although these findings suggest that focal attention is more readily guided by an angry face than by a happy face, there is an equally plausible alternative interpretation. Perhaps the reason it took longer to detect the target face expressing happiness than to detect the target face expressing anger is that it takes longer to search through angry distractor faces than it takes to search through happy distractor faces (Hampton et al., 1989). Indeed there is a considerable amount of evidence showing that the efficiency of visual search depends both on the nature of the target as well as on the nature of the distractor context (e.g., Duncan & Humphreys, 1989; Treisman & Gormican, 1988; Wolfe, 1994).

Another methodological issue that has confounded investigators is that it has proven difficult to determine if the observed differences in the speed with which faces expressing different emotions are detected reflects a difference in the emotions expressed by the faces or a difference in the component parts or features that distinguish the faces. By definition, faces expressing different emotions, such as anger and happiness, are composed of different composites of features. Given these differences, any evidence showing differential guidance of attention by unattended faces expressing different emotions can often be accounted for in terms of the different features rather than in terms of the different emotions expressed by the faces (e.g., Nothdurft, 1993; Purcell et al., 1996; White, 1997). For this reason, it is absolutely critical that investigators employ various methodological strategies for ruling out potential feature based explanations of findings.

Finally, confusion exists around the question of what constitutes satisfactory evidence that unconsciously perceived information has guided attention. In a number of studies, the underlying assumption has been that the only satisfactory evidence that a face guides attention is a pattern of findings showing that the speed with which a face is detected is relatively unaffected by the number of distractor faces (e.g., Fox et al., 2000; Nothdurft, 1993; Hampton et al., 1989; Öhman et al., 2001; Purcell et al., 1996; White, 1997). In other words, the slope of the search function across increasing numbers of distractors should be relatively flat. A flat search function showing that a target face pops out when it is embedded in displays of distractor faces certainly provides strong evidence for the guidance of attention. However, a flat search function is not the only evidence that can be used to show the importance of unconsciously perceived information in guiding attention. Another way to establish the role of unconsciously perceived information in guiding attention is to compare the slopes of the search functions for locating different targets. In this way, it is possible to assess whether the different targets lead to *relatively* more or less guidance of attention (see Smilek, Eastwood, & Merikle, 2000; Wolfe, 1998). Therefore, by comparing the slopes of the search functions for locating faces expressing positive and negative emotions, it is possible to determine whether the positive or negative emotional expression is the more effective expression for guiding attention.

When these methodological complications have been addressed, results from the visual search task have indeed demonstrated that unconsciously perceived facial expressions attract attention, resulting in an awareness of the emotionally expressive face (e.g., Eastwood et al., in press; Eastwood, Smilek, & Merikle, 2001; Fox et al., 2000; see also Öhman et al., 2001). For example, recently we (Eastwood et al., in press; 2001) have argued that the emotion expressed in a face that is outside of awareness can be perceived and bias the selection process by which emotionally expressive faces are brought into awareness. In the experiments reported by Eastwood et al., participants

searched displays of faces for the location of a unique face expressing either a positive or a negative emotion. The unique face was embedded among a varying number of distractor faces expressing neutral emotion. We found that increasing the number of distractor faces had a smaller impact on the time required to detect the negative face compared to the positive face. From these results we concluded that faces expressing negative emotion attract attention and thereby gain access to awareness more effectively than faces expressing positive emotion.

Theoretically comparable results have also been found by examining observer's error rates when searching for the presence or absence of friendly and threatening faces embedded in neutral face distractors (i.e., Öhman et al., 2001). Specifically, in experiments two and three Öhman et al. (2001) found significant interactions between set size and target emotion such that for threatening faces, a minimal decrement in performance was evident, whereas for friendly faces, observers made notably more errors as set size increased. In summary, this pattern of findings suggests that for the friendly target faces observers traded accuracy for speed at the larger set sizes; therefore, differences between the threatening and friendly target faces were evident in error rates rather than reaction times.

In summary, recent research, using the more ecologically valid visual search task, has demonstrated that attention is preferentially attracted by unconsciously perceived negative faces so that observers become aware of negative faces more rapidly (or accurately) than positive faces. By demonstrating such differential attraction of attention, support was found for the more general conclusion that the emotion expressed by a face that is outside of awareness can be perceived and bias the selection process by which emotionally expressive faces are brought into awareness.

5. Conclusions and implications for future research

To establish the *existence* of unconscious perception in the laboratory, investigators have typically sought conditions under which unconsciously perceived information *remains* outside of awareness while still exerting an influence on the observer. As discussed earlier, two distinct methodologies have been most commonly employed; namely, the method of dissociating measures of conscious and unconscious perception, and the method of demonstrating qualitatively different influences of conscious and unconsciously perceived stimulus information. If, as we are suggesting here, one of the consequences of perceiving facial expression without awareness is that attention is attracted to the facial expression, thereby resulting in an awareness of the emotionally expressive face, the potential limitation of these existing methodologies becomes readily apparent. The important finding that unconsciously perceived facial expressions do not remain unconscious, but rather draw an observers' attention to the faces so that they are perceived with awareness would have never been discovered using previous methodologies.

We believe that our consideration of the functions of unconsciously perceived emotional faces has implications beyond this domain. In many domains in psychology there emerge specific methodologies (or paradigms) that become the gold standard for studying various phenomena. The dissociation and qualitative difference approaches are good examples of such paradigms in studies of unconscious perception. It is important to realize, however, that the methods we use to study a phenomenon constrain and determine the conclusions we make. On first glance this claim may seem trivially obvious and in no need of re-asserting. However, the present review provides a good

example of how this point can easily be missed; we must be constantly vigilant to the limits imposed by our methodological tools.

One way to ensure that our methods do not lead us astray is to consider the possible *functions* of the phenomenon in question. We believe that a critical aspect of any behaviour or process is its 'function' and, therefore, that psychologists should study human behaviour by considering the whole person embedded in their real-life context and performing real world tasks. This point goes well beyond simply using ecologically valid *stimuli* in artificial laboratory settings. We are arguing that in addition to using ecologically valid stimuli, researchers also need to use more ecologically valid *tasks/situations*. It is humbling for us to consider the fact that our own work on how emotional faces guide attention is still far from meeting this ecological goal. And we hope to move further towards this goal in our future studies.

Ultimately, new methods and procedures will have to be developed in order to study "cognition in the wild" (Hutchins, 1995; see also Kingstone, Smilek, Ristic, Friesen, & Eastwood, 2003). Neisser (1982), for example, has argued that psychologists should ground their research and theories in everyday behaviour, rather than experimental procedures. By doing so, he asserted, we will be able to "find out what really happens in the world around us, and that will be worth knowing in any imaginable future" (p. 10). It is essential for cognitive psychology to embrace the critically important task of studying cognition in a manner that has relevance to real-life situations.

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