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Anxiety and sensitivity to eye gaze in emotional faces

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Abstract

This paper reports three studies in which stronger orienting to perceived eye gaze direction was revealed when observers viewed faces showing fearful or angry, compared with happy or neutral, emotional expressions. Gaze-related spatial cueing effects to laterally presented fearful faces and centrally presented angry faces were also modulated by the anxiety level of participants, with high- but not low-state anxious individuals revealing enhanced shifts of attention. In contrast, both high- and low-state anxious individuals demonstrated enhanced orienting to averted gaze when viewing laterally presented angry faces. These results provide novel evidence for the rapid integration of facial expression and gaze direction information, and for the regulation of gaze-cued attention by both the emotion conveyed in the perceived face and the degree of anxiety experienced by the observer.

Keywords: Angry; Attention; Cueing; Fear; Happy; Spatial

1. Introduction

Perception of eye gaze is fundamental to our assessment of another person's direction of attention (Langton, Watt, & Bruce, 2000). It underlies the inferences we make about other people's states of mind and intentions, activities referred to as 'social cognition' (Baron-Cohen, 1995; Kleinke, 1986). Gaze direction in others can also signal locations of potential interest in the environment, evolving possibly from the need to detect predators and other sources of threat (Baron-Cohen, 1995).

Given the significance of eye gaze perception in social communication and survival-related behaviour, it is not surprising that the eyes are particularly salient and attention-grabbing features (Emery, 2000; Langton et al., 2000). For example, pattern viewing studies reveal that humans (and monkeys) devote substantially more of their fixations to the eyes than to other internal facial features (Luria & Strauss, 1978; Nahm, Perret, Amaral, & Albright, 1997). This bias towards inspecting the eyes is apparent very early in ontogeny, at around 2 months of age (Maurer & Salapatek, 1976). Slightly later, infants (and monkeys) at around 3 or 4 months of age begin to follow gaze direction and to shift their own attention in a corresponding manner (Ferrari, Kohler, Fogassi, & Gallese, 2000; Hood, Willen, & Driver, 1998; Scaife & Bruner, 1975).

In humans, perceived gaze in faces can elicit strong, reflexive orienting, emerging rapidly at around 100 ms after the onset of the gaze stimulus, and occurring even when gaze direction is irrelevant to the task (Driver et al., 1999; Friesen & Kingstone, 1998; Hietanen, 1999; Langton & Bruce, 1999). Rapid orienting has also recently been demonstrated using non-predictive arrows (Ristic, Friesen, & Kingstone, 2002; Tipples, 2002). However, only the hemisphere specialized for face processing (i.e., right hemisphere) was found to be involved in mediating shifts of attention to eye gaze in patients whose

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cerebral hemispheres had been surgically disconnected, whereas both hemispheres were involved in reflexive shifts of attention when central arrows were presented (Kingstone, Friesen, & Gazzaniga, 2000; Ristic et al., 2002). Thus, although reflexive orienting to non-predictive central cues is not unique to biologically relevant stimuli, eye gaze would still appear to be "special" in the sense that dedicated brain circuits seem to subserve this process (e.g., Ristic et al., 2002).

Several studies, using neurophysiological, neuropsychological, functional neuroimaging, and electrophysiological techniques, have examined the brain regions recruited during perception of eye gaze. Many studies suggest the involvement of superior temporal sulcus (STS) and adjacent areas of the temporal lobe (Hoffman & Haxby, 2000; Perrett et al., 1985), and amygdala (Brothers, Ring, & Kling, 1990; Young et al., 1995). Reciprocal connections exist between these areas and cortical regions involved in spatial attention, such as cingulate and parietal cortex (Harries & Perrett, 1991; Perrett et al., 1990; Seltzer & Pandya, 1978). Functional neuroimaging studies have shown that the intraparietal sulcus (IPS) (Hoffman & Haxby, 2000; Puce, Allison, Bentin, Gore, & McCarthy, 1998) and lateral occipitotemporal junction (Puce et al., 1998; Watanabe, Kakigi, & Puce, 2001), both of which are implicated in covert shifts of spatial attention (Corbetta, Shulman, Miezin, & Petersen, 1995; Gitelman et al., 1999) are activated in response to eye gaze movements. These findings have been interpreted as reflecting the engagement of a spatial attention network in the brain for analyzing the direction of another's gaze and shifting attention to the location indicated by the gaze (e.g., Hoffman & Haxby, 2000; see also Vuilleumier, 2002). It should be noted, however, that although perceived gaze can elicit reflexive orienting via connections in the brain from specialised eye processing regions to spatial attention areas, initial attention to the face is required to enable this reciprocal process to occur (Vuilleumier, 2002).

Emotional facial expressions represent further sources of information about the mental states of other individuals, important for the regulation of social behaviour and for the anticipation of biologically and socially significant events (Ekman & Oster, 1979). The emergence of facial expression discrimination occurs soon after birth (Field, Woodson, Greenber, & Cohen, 1982; Nelson & de Haan, 1997), suggesting the existence of partly hard-wired mechanisms in the human brain for decoding facial affect (see also Sackett, 1966).

Several interconnected brain regions would appear to underlie the processing of facial expressions, including medial prefrontal and orbitofrontal cortex (Kawasaki et al., 2001; Vuilleumier, Armony, Driver, & Dolan, 2001), the amygdala (Anderson & Phelps, 2000; Morris et al., 1996), and right temporal, anterior cingulate, and insular cortices (Phillips et al., 1997; Sprengelmeyer, Rausch, Eysel, & Przuntek, 1998).

Facial emotion, particularly fearful and angry expressions, conveys a special processing advantage in being analyzed rapidly in the brain (~120 ms) in parallel with the structural encoding of faces (Eimer & Holmes, 2002; Eimer, Holmes, & McGlone, 2003; Kawasaki et al., 2001), and evoking fast autonomic responses (Globish, Hamm, Esteves, & Öhman, 1999; Öhman & Soares, 1994). Studies measuring reaction times (RTs) have also demonstrated the capacity of negative emotional expressions to draw attention rapidly and involuntarily (Armony & Dolan, 2002; Holmes, Vuilleumier, & Eimer, 2003; Mogg et al., 2000; Öhman, Lundqvist, & Esteves, 2001), even when faces were masked rendering observers unaware of their emotional content (Mogg & Bradley, 1999; van Honk, Tuiten, de Haan, van den Hout, & Henderickus, 2001).

Neural responses in the amygdala have been demonstrated following the presentation of masked (i.e., 'unseen') emotional faces (Morris, Öhman, & Dolan, 1999; Whalen et al., 1998) and to emotional faces appearing outside the viewer's focus of spatial attention (Vuilleumier et al., 2001). A rapid and coarse subcortical thalamo-amygdala processing route, as described in many psychophysiological and neurophysiological investigations (see LeDoux, 2000, for a review), has been postulated as being involved in such automatic processing of facial affect (Holmes, Green, & Vuilleumier, 2005; Morris et al., 1999; Vuilleumier, Armony, Driver, & Dolan, 2003; Whalen et al., 1998). Some recent studies, however, have revealed that neural activation evoked by emotional faces can be gated if insufficient spatial attention resources are available (Eimer et al., 2003; Holmes et al., 2003; Pessoa, McKenna, Gutierrez, & Ungerleider, 2002), and briefly presented or masked face images may well receive a full cortical analysis (Keysers, Xiao, Földiák, & Perrett, 2001). Such findings have forced a reconsideration of the role of a "quick-and-dirty" subcortical route for processing emotional expression in faces.

In addition to observations from behavioural, psychophysiological, and neuroimaging investigations, neuropsychological studies have revealed preferential processing of emotionally expressive faces in patients whose mechanisms of visual spatial attention have been disrupted through brain damage (Fox, 2002; Vuilleumier & Schwartz, 2001). This would suggest that feedback pathways, dissociable from the fronto-parietal network implicated in visual attention, and projecting most likely from the amygdala, enhance the representation of emotional facial expressions in visual cortices (Amaral, Price, Pitkanen, & Carmichael, 1992; Armony & Dolan, 2002; Lang et al., 1998).

It is clear from these data that vast areas of overlap exist between eye gaze and emotional expression processing. To begin with, there would appear to be a similar morphology of brain regions involved in both types