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The influence of emotional faces on the spatial allocation of attention

Sheyan J. Armaghani, Gregory P. Crucian, Kenneth M. Heilman *

Department of Neurology and Center for Neuropsychological Studies, University of Florida College of Medicine, Gainesville, FL, USA
Malcom Randall Veterans Affairs Medical Center, Gainesville, FL, USA

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ABSTRACT

Background objectives: Studies suggest that the right hemisphere is dominant for emotional facial recognition. In addition, whereas some studies suggest the right hemisphere mediates the processing of all emotions (dominance hypothesis), other studies suggest that the left hemisphere mediates positive emotions the right mediates negative emotions (valence hypothesis). Since each hemisphere primarily attends to contralateral space, the goals of this study was to learn if emotional faces would induce a leftward deviation of attention and if the valence of facial emotional stimuli can influence the normal viewer's spatial direction of attention. *Methods:* Seventeen normal right handed participants were asked to bisect horizontal lines that had all combinations of sad, happy or neutral faces at ends of these lines. During this task the subjects were never requested to look at these faces and there were no task demands that depended on viewing these faces. *Results:* Presentation of emotional faces induced a greater leftward deviation compared to neutral faces, independent of where (spatial position) these faces were presented. However, faces portraying negative emotions tended to induce a greater leftward bias than positive emotions. *Conclusions:* Independent of location, the presence of emotional faces influenced the spatial allocation of attention, such that normal subjects shift the direction of their attention toward left hemispace and this attentional shift appears to be greater for negative (sad) than positive faces (happy).

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1. Introduction

The brain has a limited capacity to process simultaneous information and there is more sensory information coming into the brain than the brain can fully process. In addition, even in the absence of stimuli, the human brain has the ability to activate sensory–perceptual and semantic–conceptual representations, and attending to these internal representations can further reduce the capacity to fully process incoming stimuli. Thus, the brain requires a means by which it can triage afferent input so that stimuli that are important to the person are fully processed and those that are not important (noise) do not undergo full processing. The triage processing system used by the brain is called attention.

A person can decide, based on motivational states and long term goals or intentions, the stimuli to which s/he should attend. This is called 'top down' or intentional attention. Alternatively, in the absence of an intentional goal, some stimuli, such as novel stimuli, will automatically draw a person's attention. Because of their saliency, emotional faces can capture attention more readily than other objects (Vuilleumier & Schwartz, 2001; Mack & Rock, 1998; Palermo & Rhodes, 2007). It is unclear, however, if faces displaying emotional expressions, shown in either right or left hemispace (to the right or left of the body's midsagittal plane) are more likely to capture a person's attention than emotional faces displayed in the opposite hemispace. It is also unclear if, independent of the location of the face, the presentation of certain specific forms of emotional facial expressions (e.g., positive emotions such as a happy face versus negative emotions such as a sad face) might induce spatial (right versus left) attentional biases.

There are several neuropsychological hypotheses that can be used in an attempt to predict the side of space to which people would attend when viewing emotional faces. The dominance hypothesis predicts that the perception and processing of emotional faces is mediated by the right hemisphere (Heilman, Watson, & Valenstein, 2003). Multiple studies have shown that independent of the valence of the emotion displayed on a face, patients with right hemisphere damage are more likely to be impaired at discriminating–comprehending emotional facial expressions than are those with left hemisphere damage (DeKosky, Heilman, Bowers, & Valenstein, 1980; Bowers, Bauer, Coslett, & Heilman, 1985). Functional imaging has provided converging evidence for this facial emotional dominance hypothesis

* Corresponding author at: Department of Neurology, University of Florida College of Medicine, Gainesville, FL 32610, USA.
E-mail address: heilman@neurology.ufl.edu (K.M. Heilman).

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(Ishai, Schmidt, & Boesiger, 2005). In addition, a tachistoscopic study of normal subjects showed that the emotional expression of faces on cartoons were more accurately recognized in the left visual field (right hemisphere) than the right visual field (Ley & Bryden, 1979) and Munte et al. (1998) showed that there is greater evoked response potential (ERP) activity in the right than left hemisphere during emotional face processing. Thus, based on these studies it might be more likely for emotional faces that are presented in either side of space to induce right hemispheric activation, but this activation may be even greater for those faces presented in left (versus right) viewer-centered hemispace.

An alternative theory, the valence hypothesis, posits that the right hemisphere mediates negative emotions such as sadness and the left hemisphere mediates positive emotions such as happiness (Borod et al., 1998; Silberman & Weingartner, 1986). This association was observed in studies of brain impaired subjects (Starkstein, Robinson, & Price, 1987) as well as physiological activation studies (Davidson, Mednick, Moss, Saron, & Schaffer, 1987). In a facial emotion recognition study that used tachistoscopic presentations (Reuter-Lorenz, Givis, & Moscovitch, 1983), right-handed subjects were shown emotional faces in one hemifield (right versus left) while a neutral face was shown in the opposite hemifield. These investigators found that recognition reaction times were faster when happy faces were presented in the right hemifield and sad faces in the left hemifield. These results support the valence hypothesis since the happy faces in the right hemifield should be processed by the left hemisphere and vice versa for the sad faces. In a similar study, normal subjects were shown cartoon images of faces expressing emotions ranging from extremely positive to extremely negative and these images were placed in either the right or left visual field (Van Strien & Van Beek, 2000). The participants were asked to rate the faces as either positive or negative. Compared to men, women rated faces more positively, especially in response to right visual field presentations. Women rated neutral and mildly positive faces more positively in the right than in the left visual field, whereas men rated these faces consistently across visual fields. Thus, the results of this study were mixed as women performed according to the valence hypothesis but the men did not. In a review of over 20 emotional perception laterality studies (Mandal & Ambady, 2004) provide additional evidence in support of the valence hypothesis. Thus, it is possible that when presented with happy faces, it would be more likely for normal subjects to attend to these faces when they are presented in right than left hemispace. And when presented with sad faces, they would be more likely to attend in the opposite direction. It is also possible that there might be an interaction between this dominance and valence hypotheses.

Independent of the side of presentation, seeing a meaningful stimulus such as an emotional face might also induce asymmetrical alterations in brain function, such that the areas that process these faces become more activated than areas not involved in this process. Each hemisphere primarily attends to contralateral hemispace (Kinsbourne, 1970), and thus when there is asymmetrical hemispheric activation, a person might be more likely to attend to stimuli or to portions of stimuli that are contralateral to this more activated hemisphere. Therefore, according to the valence hypothesis mentioned above, independent of the side of presentation, faces that display a negative emotion (sad) might activate the right hemisphere more than the left and bias attention toward left hemispace and faces that display a positive emotion (happy) might bias attention more to the right. In contrast, according to the dominance hypothesis, independent of the side of presentation, when seeing either a face expressing a negative emotion (e.g., sad) or a positive emotion (e.g., happy) attention would be directed toward left hemispace. There is also the possibility that there can be an interaction between these effects predicted by these two hypotheses such that independent of the emotion expressed on a face, facial emotional will induce right hemisphere activation and a leftward attentional bias, but this bias will be even greater for those faces that express a negative than positive emotion.

When people direct their attention to an object, they perceive that object's magnitude as being greater than the magnitude of an identical object to which they are devoting less attention (Chatterjee, Mennemeier, & Heilman, 1992). Thus, measuring estimates of magnitude in different portions of viewer-centered space is technically one of the best means of assessing the spatial allocation of directed attention. The line bisection task (Liepmann, 1900) has been used to assess attentional asymmetries in patients with hemispheric lesions. In general, when patients with hemispheric injury attempt to perform line bisections they deviate toward the lesioned hemisphere (Heilman et al., 2003). These results suggest that these patients' attention is biased to the ipsilesional part of space and this attentional bias toward the segment of the line that is ipsilateral to the lesion makes this part of the line appear relatively larger than an equal segment that is in the less attended portion of space which is contralateral to lesioned hemisphere. Since hemispatial alteration of attention can be measured by the line bisection task, if the presence of faces expressing emotions alters the allocation of attention, then the line bisection task might be an ideal means of testing the valence versus dominance emotional face-spatial attention hypotheses. Thus, in this study the line bisection task was used to assess how emotional faces placed on the sides of lines influence normal subjects' allocation of spatial attention.

2. Methods

2.1. Participants

Twenty participants (10 women and 10 men) with an average age of 21.61 years and 13.8 years of education volunteered for testing. Potential subjects were screened with a questionnaire and exclusionary criteria included history of head injuries, alcohol or drug abuse, learning disabilities, neurological diseases, seizures, or psychological–psychiatric disorders. Three participants revealed a history of psychological issues (treatment was sought) and therefore, were subsequently excluded from the study, resulting in the data of 17 participants being included in these analyses. The participants all had normal or corrected to normal vision at the time of testing and all were right-handed by self-report. All participants provided written informed consent approved by the Institutional Review Board of the University of Florida.

2.2. Apparatus

We used 9 different types of test stimuli, each consisting of a black line (253×2 mm) placed centrally on legal size paper (216×355 mm). Black-and-white photographs of one actress were taken from the Florida Affect Battery (Bowers, Blonder, & Heilman, 1992) depicting a happy (H), sad (S), or neutral (N) face as illustrated in Fig. 1. To avoid perceptual biases induced by the presentation of asymmetrical arrays, faces were always presented on both sides of the line test stimuli. These photographs were presented bilaterally 10 mm to the right and left ends of the horizontal lines (the intersection of two spatial planes that are anterior but parallel to the subjects' coronal and transverse planes). The test stimuli were arranged utilizing a similar coding method as that used by Tamietto, Corazzini, de Gelder, and Geminiani (2006). The unilateral emotional face condition (UEC) contained an emotional (H or S) face on either the left or right side of the line paired with an unemotional or neutral (N) face on the other side. The