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Immediate effects of exposure to positive and negative emotional stimuli on visual search characteristics in patients with unilateral neglect

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ABSTRACT

The performance of patients with unilateral neglect (UN) in tasks demanding visual attention is characterized by contralesional disadvantage which is markedly unstable in magnitude. Such instability of the attentional system is seen very clearly in clinical practice and thus far has no satisfying explanation. Here we examined the immediate effect of exposure to non-lateralized emotional stimuli on UN patients' attentional bias and performance variability. We tested eight right-hemisphere damaged stroke patients with left-sided neglect and eight age-matched healthy subjects in a visual conjunction-search task, each trial performed immediately after viewing a centrally-presented picture, which was emotionally negative, positive or neutral. Both performance bias and variability in performing the search task was analyzed as a function of the valence of the picture, and a method for analyzing reaction time (RT) variance in a small sample is introduced. Overall, UN subjects, but not controls, were slower and more variable in their RT for left- compared to right-sided targets. In the UN group, detecting left-sided targets was significantly slower in trials that followed presentation of negative pictures as compared to positive pictures, regardless of the fact that both picture types were judged as equally arousing by the patients. Moreover, UN patients exhibited larger performance variance on the left then on the right, and negative emotional stimuli were associated with larger variance asymmetry than positive emotional stimuli. Examining the coefficient of variation pointed to a possible dissociation between the effects of emotional stimuli on the lateralized RT mean (reflecting attentional bias) and on the lateralized RT variance (reflecting system instability). We conclude that emotional stimuli affect the spatial imbalance of both performance speed and stability in UN patients.

1. Introduction

Unilateral neglect (UN) is characterized by failure of salient contralesional stimuli to activate an orienting response, attract attention and generate conscious awareness, a failure that cannot be fully accounted for by sensory or motor loss (Mesulam, 2002). UN is a strong predictor for unfavorable prognosis following right hemisphere stroke (Katz, Hartman-Maeir, Ring, & Soroker, 1999). Therefore its understanding has both theoretical and clinical-therapeutic implications. Although the hallmark of the syndrome – inattention and neglect – is strongly lateralized, there is a growing body of research examining the contribution of non-spatially lateralized deficits (Robertson, 1999; Robertson, Mattingley, Rorden, & Driver, 1998; Van Vleet & Robertson, 2006) and mechanisms (He et al., 2007; Husain & Rorden, 2003; Robertson, 2001). The spatial and the non-spatial components interact with each other and create the complex clinical picture of UN (Corbetta & Shulman, 2011; Husain & Rorden, 2003).

Typically, UN patients miss or are slower to find targets on the left of a search array, relative to their detection accuracy and reaction time (RT) on the right side (Mesulam, 2002). Patients' performance can be modified by various external manipulations, such as lateralized cues (Posner, Walker, Friedrich, & Rafal, 1984; Van Vleet & Robertson, 2006), non-lateralized cues affecting vigilance, arousal and alertness (Robertson et al., 1998; Thimm, Fink, Küst, Karbe, & Sturm, 2006; Van Vleet & Robertson, 2006) and by internal self-generated intentions (Robertson, 2001). The performance is also characterized by unexplained variability across and within patients (Mesulam, 2002): performance during a task is marked by large variance and inconsistency (Anderson, Mennemeier, & Chatterjee, 2000; Bartolomeo, Siéroff, Chokron, & Decaix, 2001) and performance on multiple administrations of the

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same test may change during the course of the day (Small & Ellis, 1994), although not in all cases (Levy, Blizzard, Halligan, & Stone, 1995). Additionally, the patients' neglect characteristics change over time (Hamilton, Coslett, Buxbaum, Whyte, & Ferraro, 2008), not necessarily in a linear fashion, with occasional relapses during the recovery phase (Jehkonen, Laihosalo, Koivisto, Dastidar, & Ahonen, 2007). Some of the instability in the functioning of the attentional systems, observed in UN patients, may reflect fluctuations in the patients' affective state or processing of emotional stimuli, as emotions are a powerful motivational force (Damasio, 1999; Panksepp, 1998, 2007) that affect overt behavior, cognitive processing (Dolan, 2002; Rosler et al., 2005; Scherer, 2005) and consciousness (Damasio, 1999).

The relationship between emotion and attention has been extensively studied in recent years, revealing a complex interaction (for reviews see Pourtois, Schettino, & Vuilleumier, 2013; Raymond, 2009; Vuilleumier & Driver, 2007; Yiend, 2010). In healthy subjects, many studies find enhanced processing or preferable response to emotionally non-neutral stimuli (e.g., Hartikainen, Ogawa, & Knight, 2000; Pereira et al., 2006; Rowe, Hirsh, & Anderson, 2007; Simon-Thomas & Knight, 2005; Simon-Thomas, Role, & Knight, 2005), with some exceptions (e.g., Fox, Russo, Bowles, & Dutton, 2001; Kitayama, 1991; Lipp, Derakshan, Waters, & Logies, 2004). Most studies indicate that negative stimuli are detected faster and more efficiently than neutral stimuli (Eastwood, Smilek, & Merikle, 2001; Fox et al., 2000; Hansen & Hansen, 1988; but see Lipp et al., 2004). Depending on the task, aversive or threatening stimuli may affect performance by several alternative mechanisms including withdrawing attention away from threatening stimuli (Bradley et al., 1997; Mather & Carstensen, 2003; Yiend, 2010), attraction of attention (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; Mogg et al., 2000; Wilson & MacLeod, 2003), difficulty to disengage (Koster, Crombez, Verschuere, & De Houwer, 2004) or a variation of the phenomena known as inhibition of return (IOR, Lupianez, Klein, & Bartolomeo, 2006; Posner et al., 1984), whereby attentional facilitation is followed by inhibition. Finally, it is also not settled yet whether emotional stimuli need attention resources in order to be processed (Okon-Singer, Tzelgov, & Henik, 2007; Pessoa, 2005, 2009; Pessoa & Adolphs, 2010; Pessoa, Kastner, & Ungerleider, 2002; Wiens, Sand, Norberg, & Andersson, 2011) or whether the emotional content may be perceived pre-attentively, perhaps by sub-cortical circuits (Vuilleumier & Driver, 2007).

Some of the interactions between emotional processing and attention may be related to the fact that both functions seem to be asymmetrically distributed over the cerebral hemisphere. The ventral attention system, which is frequently affected in UN, is more prominent in the right hemisphere than on the left, and the right and left hemispheres compete for directing attention to the contralateral side via the dorsal attention system (Corbetta, Patel, & Shulman, 2008; Corbetta & Shulman, 2002, 2011). Emotional processing is also lateralized (Borod, 1992; Borod, Bloom, Brickman, Nakhutina, & Curko, 2002; Sherratt, 2007; Tsuchiya & Adolphs, 2007; Wager, Phan, Liberzon, & Taylor, 2003) although the exact nature of this lateralization is less clear. The "right hemisphere hypothesis" claims that the right hemisphere dominates processing and expression of emotions of all valences (Adolphs, Damasio, Tranel, & Damasio, 1996; Levine & Levy, 1986). In contrast, according to the "valence hypothesis" the right hemisphere supports processing of negative emotions, while the left hemisphere supports processing of positive emotions (Davidson, 1984, 1995; Davidson & Irwin, 1999). Under both accounts, it seems reasonable to assume that engaging in emotional processing may affect attention by altering the inter-hemispheric balance.

The interplay between attention and emotions is especially relevant in UN (see review by Dominguez-Borras, Saj, Armony, & Vuilleumier, 2012), which is considered an attentional deficit (Mesulam, 2002). Indeed, emotional left-side stimuli are extinguished less in simultaneous bilateral presentation (Fox, 2002; Grandjean, Sander, Lucas, Scherer, & Vuilleumier, 2008; Tamietto, Geminiani, Genero, & de Gelder, 2007; Vuilleumier et al., 2002; Vuilleumier & Schwartz, 2001a, 2001b), detected more in a unilateral presentation (Grabowska et al., 2011) and reduce the rightwards bias in a line-bisection task (Tamietto et al., 2005). It was suggested that these effects of emotional stimuli are due to attention mechanisms that are partly independent from other circuits controlling spatial and object-based attention mechanisms (Dominguez-Borras et al., 2012; Lucas & Vuilleumier, 2008; Vuilleumier, 2005).

In the above studies the emotional stimuli were presented laterally, and the facilitation seen with emotional stimuli could be explained by postulating that emotional stimuli, more than neutral stimuli, attract spatial attention to their position in space, in a bottom-up manner. Alternatively, however, the emotional content might affect processing regardless of the spatial position of stimulus, for example due to different engagement of the two hemispheres as noted above. To examine the effect of emotional content regardless of spatial lateralization, stimuli need to be presented without spatial bias.

Soto et al. (2009) examined the accuracy level in visuospatial tasks in three UN patients who listened to their preferred music, contrasted with non-preferred or silence. Listening to the preferred music ameliorated neglect. However, it should be noted that the two emotional music conditions were differentiated not just by valence but also by familiarity. While the preferred music was selected by each patient, based on personal preference, the non-preferred music was selected by the experimenters. Therefore, the preferred music was not only enjoyable and pleasant but also familiar and predictable, as opposed to the non-preferred music which might have drawn more attention due to its novelty. Stimulus novelty influences perception (Schomaker & Meeter, 2012) the level of interest (Silvia, 2005), physiological response (Bradley, Lang, & Cuthbert, 1993) and processing style (Forster, Liberman, & Shapira, 2009) and may have affected the patients' performance beyond its emotional effect. In a single patient, the lingering effect of music following its termination was tested using a positive, a negative and another positive block. Each block started with induction of mood: music-video of the patient's preferred artist in the positive blocks and a conversation on a disturbing subject in the negative block. In order to sustain the induced mood, a positive emotional picture was presented before each trial in the positive blocks, and similarly, negative pictures were presented in the negative block. This manipulation yielded lower accuracy levels in the search task in the negative block relative to the positive blocks. This block design leaves open the question of the effect of transient emotional stimuli. There is evidence that emotional stimuli of different valence can induce distinct affects on a trial by trial basis even when presented within a mixed block (e.g., Smith, Low, Bradley, & Lang, 2006).

In the present study we sought to examine how non-lateralized visual emotional stimuli transiently influence UN patients' performance in a subsequent visual search task, while focusing on the valence of the stimuli. We used pictures from the International Affective Picture System (IAPS: Lang, Bradley, & Cuthbert, 2005), a standardized pool of color pictures of various contents with norms for valence and arousal. We selected non-arousing pictures of three different valence levels: negative (low score), neutral (medium score) and positive (high score) and presented them in a random order. The pictures were presented centrally in order to prevent spatial attentional bias. All the stimuli were novel to the subjects and were presented once. A single trial of a conjunction search task was performed following each picture presentation.