Biological Psychology 122 (2017) 69–79

Contents lists available at ScienceDirect

Biological Psychology

journal homepage: www.elsevier.com/locate/biopsycho

Temperament differentially influences early information processing in men and women: Preliminary electrophysiological evidence of attentional biases in healthy individuals

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ARTICLE INFO

Article history:
Received 28 June 2015
Received in revised form 5 July 2016
Accepted 5 July 2016
Available online 7 July 2016

Keywords:
Attentional bias
Dot-probe task
Temperament
Gender
ERP
P1
N1
P2

ABSTRACT

Preferential processing of threat-related information is a robust finding in anxiety disorders. The observation that attentional biases are also present in healthy individuals suggests factors other than clinical symptoms to play a role. Using a dot-probe paradigm while event-related potentials were recorded in 59 healthy adults, we investigated whether temperament and gender, both related to individual variation in anxiety levels, influence attentional processing. All participants showed protective attentional biases in terms of enhanced attention engagement with positive information, indexed by larger N1 amplitudes in positive compared to negative conditions. Taking gender differences into account, we observed that women showed enhanced attention engagement with negative compared to neutral information, indicated by larger P2 amplitudes in congruent than in incongruent negative conditions. Attentional processing was influenced by the temperament traits negative affect and effortful control. Our results emphasize that gender and temperament modulate attentional biases in healthy adults.

1. Introduction

Biased cognitions are common symptoms in psychopathology, especially in anxiety disorders and depression (Beck, 1987). A multitude of studies demonstrated that these cognitive distortions are accompanied or even caused by biased attentional processes (e.g., Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & Van Ijzendoorn, 2007; Mingtian, Xiongzhao, Jinyao, Shuqiao, & Atchley, 2011; Mueller et al., 2009). Viewed from a clinical perspective, an overly sensitive threat-detection system is considered to play a key role in causing attentional biases and maintaining anxiety disorders (Bar-Haim et al., 2007). However, adopting an evolutionary perspective, humans need to be equipped with a system (i.e., the fight-flight system) enabling appropriate responses to potential sources of threat (LeDoux, 1996; Öhman, Lundqvist, & Esteves, 2001). Therefore, attentional bias tendencies might not necessarily be related to clinical symptoms, but may be also present in healthy individuals to serve adaptive functions.

On a behavioral level, attentional bias tendencies are commonly captured with dot-probe tasks (MacLeod, Mathews, & Tata, 1986), which allow for the differentiation between vigilance and difficulty to disengage from a specific stimulus (Koster, Crombez, Verschuere, & De Houwer, 2004). In the dot-probe task, two pictures (one emotional and one neutral) are presented simultaneously on a computer screen. Participants should detect the side of the target, a dot-probe which appears immediately after stimulus offset, as quickly as possible and respond via a corresponding button-press. The dot-probe appears either at the location of the emotional stimulus (congruent condition) or at the location of the neutral stimulus (incongruent condition). Responses are considered to be faster to dot-probes replacing threat-related stimuli and/or stimuli which have been attended to before (MacLeod et al., 1986). Most emotional attention paradigms (e.g., Holmes, Bradley, Kragh Nielsen,

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http://dx.doi.org/10.1016/j.biopsycho.2016.07.007
0301-0511/

& Mogg, 2009; Sass et al., 2010; Tran, Lamplmayr, Pintzinger, & Pfabigan, 2013; for a review see Bar-Haim et al., 2007) contain rather abstract stimuli with very little contextual information and hence possibly low ecological validity, such as emotional faces or words. Assuming that in everyday life not only facial emotion recognition, but also fast detection and evaluation of positive or negative situations are important for preventing harm or for engaging in beneficial social interactions (Mogg, Bradley, Miles, & Dixon, 2004), we intended to investigate whether attentional biases also occur in response to more naturalistic situations. We therefore developed a new set of pictures of complex social scenes, and investigated behavioral and ERP responses to dot-probes indicative of attentional biases.

So far, most studies on attentional biases have applied behavioral paradigms (for a review see Bar-Haim et al., 2007; Cisler, Bacon, & Williams, 2009). In healthy participants, Holmes et al. (2009) reported that attention was more strongly captured by emotional faces (happy, angry) in contrast to neutral faces, whereas Mueller et al. (2009) reported no bias tendencies toward angry or happy faces. While it is yet unclear how to explain such conflicting results, possible reasons may be that slightly different experimental paradigms have been used (e.g., a go/no go version of the dot-probe task, or different stimulus presentation durations). Koster, Crombez, Verschuere, Vanvolsem, and De Houwer (2007), for example, argued that facilitated attentional orienting toward threatening stimuli is a transient phenomenon that occurs as a function of stimulus presentation duration (i.e., observable only for 100 ms presentation durations). Moreover, reaction time data provide only a snapshot of attention, namely attention allocation at the time point of dot-probe appearance, and may be influenced by post-perceptual processes like decision making or motor responses (Handy, Green, Mangun, & Klein, 2001).

Psychophysiological methods like event-related potentials (ERPs), on the contrary, allow for continuous monitoring of attention deployment and provide a more detailed insight in the exact time course of attention allocation. Established physiological correlates of early visuospatial attention are the P1 component following cue and target presentation and the N1 component following target presentation (Hillyard, Luck, & Mangun, 1994). The P1 in response to visual stimuli is a positive-going ERP component peaking approximately between 100 and 130 ms after stimulus presentation and is maximal over parieto-occipital and occipital electrode positions (Luck, 2005). The P1 amplitude increases with the amount of attentional resources allocated toward a given stimulus (Luck, Woodman, & Vogel, 2000) and provides also an index for face categorization processes (Pizzagalli et al., 2002). Measured with a dot-probe paradigm, target-locked P1 amplitudes in healthy participants were increased to dot-probes after angry (Santesso et al., 2008) and fearful faces (Pourtois, Grandjean, Sander, & Vuilleumier, 2004) compared to happy faces. As the P1 component is also sensitive to low-level visual features such as contrast, luminance, or orientation (Luck, 2005), Mingtian et al. (2011) obtained different results by using more complex emotional and neutral pictures (i.e., IAPS database, Lang, Bradley, & Cuthbert, 2005). In their study, healthy participants paid more attention to positive stimuli as indicated by larger target-locked P1 amplitudes in congruent than in incongruent positive conditions.

The N1 component peaks around 150–200 ms post-stimulus and is considered to reflect the attentional focus and a discrimination process within the focus of attention (Olofsson, Nordin, Sequeira, & Polich, 2008). Healthy participants showed slightly larger target-locked N1 amplitudes after probes following happy faces than after angry faces (Santesso et al., 2008). In addition, the P2 component is also relevant in the context of dot-probe tasks since it is generally associated with more elaborate emotion evaluation (Carretié, Martín-Loeches, Hinojosa, & Mercado, 2001) and attentional disengagement processes (Bar-Haim, Lamy, & Glickman, 2005). Bar-Haim et al. (2005) found greater cue-locked P2 amplitudes in high-anxious compared to low anxious participants, but only to angry faces.

So far, when investigating ERPs in the dot-probe task, no standard procedure has been established. Some studies analyzed cue- as well as target-locked data (e.g., Bar-Haim et al., 2005; Eldar, Yankelevitch, Lamy, & Bar-Haim, 2010; Mueller et al., 2009; Santesso et al., 2008), while others investigated only target-locked ERPs (e.g., Mingtian et al., 2011; Pfabigan, Lamplmayr-Kragl, Pintzinger, Sailer, & Tran, 2014). In the present study, we assessed cue- and target locked data in order to capture initial attentional processes as a direct response to the cue as well as early visuospatial attention in response to the target. We assume that target-locked data provide an indirect measure of affective processing which may be more directly comparable to behavioral (i.e., reaction time) data than cue-locked data.

The observation that biased attentional processes are also present in healthy participants – although those findings could not be replicated consistently – suggests influencing factors other than clinical symptoms. While several studies (e.g., Cooper & Langton, 2006; Koster et al., 2007; Pegna, Landis, & Khateb, 2008) investigated paradigm-specific aspects like stimulus presentation duration and intensity of threat stimuli, participant-specific aspects (e.g. gender and temperament in the present study) are still less understood and seldom studied.

The fact that gender significantly influences emotional processing (Cahill, 2006) has been considered only in a few studies on attentional biases so far. On a behavioral level, threat-related attentional biases have been found to be linked to individual anxiety levels only in women (Tan, Ma, Gao, Wu, & Fang, 2011; Tran et al., 2013). Men, on the contrary, avoided threatening faces (Tan et al., 2011) or had difficulties in disengaging their attention from those stimuli, a pattern which was not related to anxiety (Tran et al., 2013). ERP findings revealed that threat-related attentional biases occurred among both genders, but at different processing stages: Men displayed stronger attentional orientation toward threatening rather than toward pleasant stimuli in early processing stages, as shown by larger P1 amplitudes after threat compared to pleasant stimuli, whereas women showed more elaborate processing of threat stimuli, indicated by prolonged latencies of the P3 component (an ERP related to context updating and stimulus relevance, Coles, Smid, Scheffers, & Otten, 1995; Polich, 2007) for threat than for pleasant stimuli (Sass et al., 2010). Pfabigan et al. (2014), on the contrary, observed overall enhanced target-locked P1 amplitudes among women compared to men, in particular after rewarding facial stimuli. However, different experimental paradigms have been applied in these studies which may at least partly explain inconsistencies in previous research on gender differences in attentional biases.

Importantly, men and women differ not only in emotional processing, but also in temperament domains (Else-Quest, Shibley Hyde, Hill Goldsmith, & Van Hulle, 2006; Wiltink, Vogelsang, & Beutel, 2006). Extending previous theoretical frameworks in temperament research, Rothbart and Bates (1998) defined temperament as "constitutionally based individual differences in emotional, motor, and attentional reactivity and self-regulation" (p. 109). Temperament comprises reactive and regulative processes, which are both mediated by automatic attention allocation mechanisms. Reactive temperamental processes are reflected in automatic attentional engagement with threat cues (Lonigan, Vasey, Phillips, & Hazen, 2004) and relate to negative affectivity, which in turn is strongly linked to trait anxiety (Clark, Watson, & Mineka, 1994; Eysenck, 1967). Temperamental reactivity is moderated by regulative temperamental factors, summarized as effortful control. Effortful control facilitates focusing attention (Derryberry