Brain and Cognition 118 (2017) 63–70

Contents lists available at ScienceDirect

Brain and Cognition

journal homepage: www.elsevier.com/locate/b&c

Socially anxious tendencies affect neural processing of gaze perception

Yuki Tsuji[a,b], Sotaro Shimada[c,*]

[a] Electrical Engineering Program, Graduate School of Science and Technology, Meiji University, 1-1-1 Higashi-Mita, Tama-ku, Kawasaki, Kanagawa 214-8571, Japan
[b] Research Fellow of Japan Society for the Promotion of Science, Kojimachi Business Center Building, 5-3-1 Kojimachi, Chiyoda-ku, Tokyo 102-0083, Japan
[c] Department of Electronics and Bioinformatics, School of Science and Technology, Meiji University, 1-1-1 Higashi-Mita, Tama-ku, Kawasaki, Kanagawa 214-8571, Japan

ARTICLE INFO

Keywords:
Social anxiety disorder
Gaze perception
P2
ERP

ABSTRACT

The gaze of others is known to be a particularly common cause of social anxiety. In the current study, we measured event-related potentials (ERPs) during gaze perception among people with or without high socially anxious tendencies (HSA). The experimental stimuli were grayscale images of the eye region of a face, showing direct or averted eye gaze (leftward gaze or rightward gaze) or closed eyes. We found that negative ERPs at a right occipito-temporal site (N170) and positive ERPs at the fronto-central region (P2) were evoked by eye gaze stimuli. While the N170 was not affected by socially anxious tendencies, the amplitude of the P2 was significantly greater in the HSA group than in the low socially anxious tendencies (LSA) group. Furthermore, P2 latency showed a significant interaction between groups and conditions: the HSA group exhibited shorter P2 latencies in response to direct gaze than averted gaze, while the LSA group did not. These results indicate that the neural processing of eye gaze is strongly influenced by socially anxious tendencies. In particular, the attentional processing of direct gaze is more prominent in individuals with HSA tendencies.

1. Introduction

Other peoples' eyes can provide valuable social context, and eye contact provides an important foundation for social interaction (Senju & Johnson, 2009). Although the gaze of others is a subtle facial cue, it plays an important role in fearfulness in social anxiety disorder (SAD), which is one of the most common psychiatric disorders (Kessler, Petukhova, Sampson, Zaslavsky, & Wittchen, 2012). Avoidance or excessive fear of situations associated with evaluation or embarrassment by others is a defining feature of SAD or social phobia (American Psychiatric Association, 2000). In particular, the gaze of others is known to commonly induce social anxiety (Den Boer, 2000). Several behavioral studies have reported that people with high socially anxious (HSA) tendencies perceived subtle averted gaze (right or left) as self-directed gaze (Gamer, Hecht, Seipp, & Hiller, 2011; Harbort, Witthöft, Spiegel, Nick, & Hecht, 2013; Schulze, Lobmaier, Arnold, & Renneberg, 2013) and exhibited a strong fear of being stared at via self-directed gaze (Schneier, Rodebaugh, Blanco, Lewin, & Liebowitz, 2011).

Several behavioral studies of gaze processing have reported that individuals with SAD perceive the gaze of others as threatening (Moukheiber et al., 2010; Weeks, Howell, & Goldin, 2013). These studies employed full face pictures as experimental stimuli and demonstrated that socially anxious subjects avoided looking at the eye region (Horley, Williams, Gonsalvez, & Gordon, 2004). These findings suggest that the gaze of others is likely to be an important factor in inducing social anxiety. However, brain activity in response to gaze has not been investigated in depth in socially anxious individuals.

Event-related potentials (ERPs) have been widely used to examine brain activity in response to others' eye gaze in healthy subjects. The N170, which occurs in response to gaze perception, has been examined in the occipito-temporal region (Carrick, Thompson, Epling, & Puce, 2007; Conty, N'Diaye, Tijus, & George, 2007; McPartland, Cheung, Perszyk, & Mayes, 2010; Nomi, Frances, Nguyen, Bastidas, & Troup, 2013). Several studies reported that the N170 amplitude was greater in response to images of the eye region alone, compared with full face images. In addition, the N170 latency was found to be longer in response to eye region images, compared with full face images (Itier, Alain, Sedore, & McIntosh, 2007; Itier, Latinus, & Taylor, 2006; Taylor, Edmonds, McCarthy, & Truett, 2001b; Taylor, Itier, Allison, & Edmonds, 2001a). Emotional face processing has also been reported to be reflected in the N170 and early visual ERPs in healthy subjects (Luo, Feng, He, Wang, & Luo, 2010). One study reported that when subjects observed emotional faces, the latency of the occipito-temporal N170 was shorter in response to faces displaying neutral and happy expressions, compared with faces displaying fearful, disgusted or sad expressions (Batty & Taylor, 2003). Several other studies reported that the

* Corresponding author at: Department of Electronics and Bioinformatics, School of Science and Technology, Meiji University, 1-1-1 Higashi-Mita, Tama-ku, Kawasaki, Kanagawa 214-8571, Japan.
E-mail address: sshimada@meiji.ac.jp (S. Shimada).

http://dx.doi.org/10.1016/j.bandc.2017.08.002
Received 14 March 2017; Received in revised form 4 August 2017; Accepted 4 August 2017
Available online 08 August 2017

amplitude of the N170 evoked by emotional faces is greater than for neutral faces (Bublatzky, Gerdes, White, Riemer, & Alpers, 2014; Herbert, Sfärlea, & Blumenthal, 2013; Williams, Palmer, Liddell, Song, & Gordon, 2006). Previous studies have also reported that threatening emotional faces (i.e., angry or fearful faces) increased the amplitude of the fronto-central P1 and P2 (Bar-Haim, Lamy, & Glickman, 2005; Eimer & Holmes, 2002; Eimer, Holmes, & McGlone, 2003; Williams et al., 2006). These findings indicate that the N170 and other early ERP components can be modulated by emotional stimuli.

Activation of ERP components modulated by emotional stimuli has also been examined among anxious subjects, including those with social anxiety (Bar-Haim et al., 2005; Mühlberger et al., 2009; Rossignol, Campanella, Bissot, & Philippot, 2013a; Rossignol, Fisch, Maurage, Joassin, & Philippot, 2013b; Rossignol, Philippot, Bissot, Rigoulot, & Campanella, 2012). Bar-Haim et al. (2005) reported that viewing angry face stimuli increased the P2 amplitude over central regions to a greater extent in high trait anxious individuals, compared with individuals with low trait anxiety. Previous studies have shown that the P2 can be used as an index of emotional processing (Carretié, Mercado, Tapia, & Hinojosa, 2001; Foti & Hajcak, 2008; Huang & Luo, 2006; Luo et al., 2010; Olofsson, Nordin, Sequeira, & Polich, 2008), is associated with greater reallocation of attentional resources to salient stimuli (Bar-Haim et al., 2005; Eldar & Bar-Haim, 2010). Moreover, several previous studies have shown that the P2 amplitude in response to threatening emotional faces (i.e. angry or fearful faces) was modulated by trait or social anxiety (Bar-Haim et al., 2005; van Peer, Spinhoven, & Roelofs, 2010). Conversely, several studies reported that the N170 was unaffected by social anxiety in emotional face processing (Mühlberger et al., 2009; Rossignol et al., 2012, 2013a, 2013b). These findings suggest that the P2 in response to threatening emotional faces (e.g., angry face stimuli) is enhanced in anxious individuals, compared with non-anxious individuals, while the N170 is not. However, the effect of SAD on these early ERP components (N170 and P2) in response to others' eye gaze has not been fully investigated.

The purpose of the current study was to examine the influence of socially anxious tendencies on ERPs during gaze perception. To this end, we compared ERPs (N170 and P2) while viewing gaze stimuli showing direct gaze, averted gaze and closed eyes, between individuals with low and high socially anxious tendencies. Behavioral evidence that individuals with SAD perceive the gaze of others as threatening (Horley et al., 2004; Moukheiber et al., 2010; Weeks et al., 2013) and ERP studies of the neural processing of threatening emotional faces in anxious individuals have indicated that the P2 is associated with anxiety (Bar-Haim et al., 2005) while the N170 is not (Mühlberger et al., 2009; Rossignol et al., 2012, 2013a, 2013b). Thus, we hypothesized that socially anxious tendencies would modulate the P2, but not the N170, during the perception of others' gaze.

2. Materials and methods

2.1. Participants

Sixteen healthy volunteers (eight females, eight males, 21 ± 1.3, mean ± SD) took part in this experiment. All participants had normal or corrected-to-normal vision and gave written informed consent to participate in the study. The experiments were approved by the ethics committee of the School of Science and Technology, Meiji University, and were conducted according to the principles and guidelines of the Declaration of Helsinki.

2.2. Social anxiety rating

Each participant's level of social anxiety was examined using the Japanese version of the Liebowitz Social Anxiety Scale (LSAS-J) (Liebowitz, 1987). The LSAS-J is a 24-item scale that measures fear and avoidance of social situations over the past week. Eleven of the items enquire into social interaction-related situations (e.g., going to a party, meeting strangers) while the remaining 13 items assess public performance situations (e.g., public speaking, eating in public places). The first set of items measures fear/anxiety related to social interaction and public performance, and the second set of items measures the tendency to avoid social interaction and public performance. Participants responded using a 4-point (0–3) Likert-type scale. The overall total score is derived by summing the fear/anxiety and avoidance ratings for all items. The total LSAS-J score ranges from 0 to 144 and the clinical cut-off point is 60 (Mennin et al., 2002). Subjects were divided into two groups: a high socially anxious group (HSA, n = 8, 4 females) and a low socially anxious group (LSA, n = 8, 4 females), on the basis of a clinical cut-off point of an LSAS-J score of 60. In this study, HSA individuals were non-clinical, but their LSAS-J scores were above the clinical cut-off point. The age of the two groups was not significantly different ($Z = 0.26$, $p > 0.1$).

2.3. Stimuli

The experimental stimuli were grayscale images of the eye region, showing either direct or averted eye gaze (leftward gaze or rightward gaze), or closed eyes (Fig. 1). The stimuli were presented at the center of a 27-in. LCD monitor using E-Prime software (Psychology Software

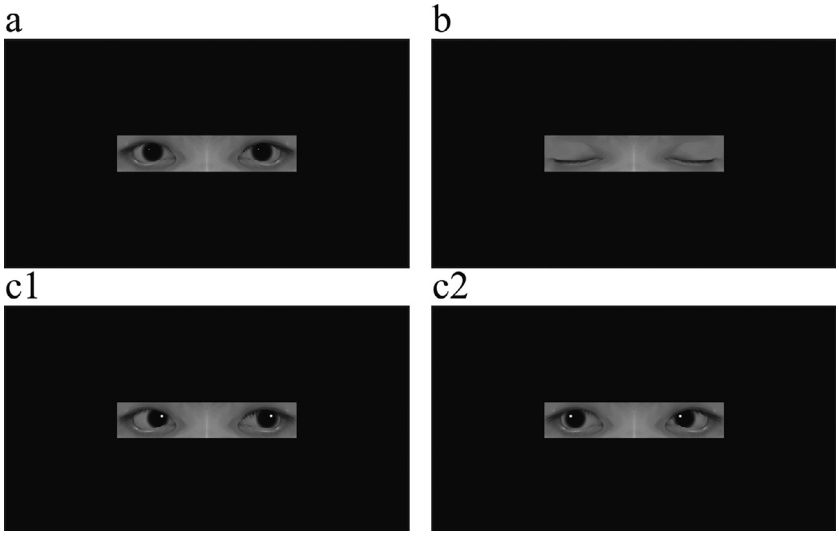

Fig. 1. Examples of the stimulus display in the experiment. (a) The direct gaze condition. (b) The closed eyes condition. (c1) The averted gaze condition (rightward gaze). (c2) The averted gaze condition (leftward gaze).