Brain and Cognition 82 (2013) 344–352

Contents lists available at SciVerse ScienceDirect

Brain and Cognition

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

Fear of negative evaluation and attentional bias for facial expressions: An event-related study

Mandy Rossignol [a,*], Salvatore Campanella [b], Cécile Bissot [a], Pierre Philippot [a]

[a] Institut de Recherche en Psychologie, Université Catholique de Louvain, Louvain-La-Neuve, Belgium
[b] Psychological Medicine, Université Libre de Bruxelles, Brussels, Belgium

ARTICLE INFO

Article history:
Accepted 26 May 2013

Keywords:
FNE
Evaluation anxiety
Face
Attention
Emotional biases
ERP

ABSTRACT

Numerous studies have shown an exacerbation of attentional bias towards threat in anxiety states. However, the cognitive mechanisms responsible for these attentional biases remain largely unknown. Further, the authors outline the need to consider the nature of the attentional processes in operation (hypervigilance, avoidance, or disengagement). We adapted a dot-probe paradigm to record behavioral and electrophysiological responses in 26 participants reporting high or low fear of evaluation, a major component of social anxiety. Pairs of faces including a neutral and an emotional face (displaying anger, fear, disgust, or happiness) were presented during 200 ms and then replaced by a neutral target to discriminate. Results show that anxious participants were characterized by an increased P1 in response to pairs of faces, irrespective of the emotional expression included in the pair. They also showed an increased P2 in response to angry–neutral pairs selectively. Finally, in anxious participants, the P1 response to targets was enhanced when replacing emotional faces, whereas non-anxious subjects showed no difference between the two conditions. These results indicate an early hypervigilance to face stimuli in social anxiety, coupled with difficulty in disengaging from threat and sustained attention to emotional stimuli. They are discussed within the framework of current models of anxiety and psychopathology.

1. Introduction

It is well established that the emotional relevance of a stimulus influences the orientation of attentional resources (Taylor & Fragopanagos, 2005; Vuilleumier, 2005; Yiend, 2010). The "dot-probe" paradigm (MacLeod, Mathews, & Tata, 1986) is one of the most frequently used methods to assess the interplay between attention and emotion on selective attention processes. In this paradigm, two stimuli, one neutral and one emotional, are presented on either side of the screen during a short interval (most commonly 500 ms). After their offset, a dot is presented in the location of one of the two cues and participants have to indicate the position or discriminate the shape of the dot as quickly as possible (see for instance Salemink, van den Hout, & Kindt, 2007). While original studies on spatial attention demonstrated that people respond more quickly to a probe stimulus presented in a cued region (Posner, Snyder, & Davidson, 1980), the emotional dot-probe has provided evidence of the increased allocation of visual attention towards threat-related cues, indexed by a decreased reaction time in response to probes following threat relative to neutral cues (Fox, Russo, & Dutton, 2002; MacLeod et al., 1986; Telzer et al., 2008).

Event-related potentials (ERPs) studies have indexed this orienting effect as quickly as 100 ms after the presentation of a validly-cued target, through an amplification of the occipitoparietal P1 component (Luck, Hillyard, Mouloua, & Hawkins, 1996). That component is generated by extrastriate cortices and reflects basic visual processing (Allison, Puce, Spencer, & McCarthy, 1999) and is enhanced for stimuli appearing in an attended location (Hillyard & Anllo-Vento, 1998; Luck et al., 1996), suggesting top-down influences on basic visual processes. Accordingly, several studies used modified versions of a cue-target paradigm to evidence enlarged P1 amplitudes to probes replacing fearful (Pourtois, Grandjean, Sander, & Vuilleumier, 2004) or angry faces (Fox, Derakshan, & Shoker, 2008; Santesso et al., 2008) as compared to neutral faces. Consequently, threat-related stimuli do have a modulatory role in the control of spatial attention in healthy individuals, in such a way that the visual processing of targets is guided by spatial attention to cues that persists over time (Holmes, Vuilleumier, & Eimer, 2003).

If emotional attention constitutes a feature of normal human cognition (Vuilleumier, 2005), anxiety increases this universal tendency to favor the processing of threatening information (Cisler & Koster, 2010; Yiend, 2010). In that context, numerous studies

* Corresponding author. Address: Institut de Psychologie, Université Catholique de Louvain, Place du Cardinal Mercier 10, 1348 Louvain-La-Neuve, Belgium.
E-mail address: mandy.rossignol@uclouvain.be (M. Rossignol).

0278-2626/$ - see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.bandc.2013.05.008

consistently reported the presence of a spatial attentional bias favoring threat in both anxious patients and high trait anxious normals (for reviews, see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007; Frewen, Dozois, Joanisse, & Neufeld, 2008). Neuroimaging data have indexed that bias by showing potentiated neural activation of the right dorsolateral prefrontal cortex in response to angry–neutral trials in high trait anxiety (Telzer et al., 2008) together with increased P1 responses for targets replacing threatening pictures in high trait anxious participants (Li, Li, & Luo, 2005). These data consistently suggest that high trait anxiety is associated with a potentiation of the preferential processing of threat.

However, data have been more mitigated in the case of social anxiety disorder (SAnD) (Bögels & Mansell, 2004; Staugaard, 2010; Yiend, 2010). Beside emotional distress in interpersonal interaction and social avoidance, fear of negative evaluation (FNE) is a core component of social anxiety (Clark & Wells, 1995; Rapee & Heimberg, 1997). In that context, a self-reported measure has been developed by Watson and Friend (1969) to evaluate the degree to which individuals fear negative evaluation from other. High FNE individuals are described as hypervigilant to external cues of social evaluation, as those conveyed by emotional faces (Rapee & Heimberg, 1997), but they may try to avoid such threatening cues in order to diminish anxious symptoms (Clark, 1999). As a matter of fact, some studies have shown the classical phenomenon of attention bias toward threatening faces in SAnD (Mogg, Philippot, & Bradley, 2004; Pishyar, Harris, & Menzies, 2008), while others have suggested that socially anxious individuals selectively attend away from emotional faces, regardless of their valence (Mansell, Clark, Ehlers, & Chen, 1999), and even from faces per se whether emotional or not (Chen, Ehlers, Clark, & Mansell, 2002).These discrepancies have been attributed to some distinctive features of the paradigms. Socially anxious individuals seem to be vigilant to faces presented for short exposure duration (Miskovic & Schmidt, 2012; Mogg & Bradley, 2002) but not for a longer presentation time (Mogg et al., 2004), which may lead to avoidance. Hence, these findings have been integrated in the vigilance/avoidance theory (Amir, Foa, & Coles, 1998; Vassilipoulos, 2005). This model postulates that SAnD individuals are vigilant to threat at the early stages of information processing, but avoid these cues at subsequent processing steps. For instance, a recent study by Moriya and Tanno (2011) showed that highly socially anxious individuals look longer at the emotional faces during the first second of stimulus exposure but they avoid these faces in the consecutive time interval. An ERP study by Mueller and collaborators (2009) supported this theory by showing higher P1 amplitudes in response to the angry–neutral face pairs but decreased P1 amplitudes when social phobic inpatients responded to targets replacing emotional (angry and happy) faces as compared to neutral ones.

Beside the role of vigilance and avoidance processes, high fear of negative evaluation scores could also be associated with difficulty in disengaging attention from angry faces after recognizing them (Moriya & Tanno, 2011). Disengagement process has been involved in attentional bias in SAnD (Klumpp & Amir, 2009) and a recent study has confirmed its impairment in connection with high FNE (Rossignol, Philippot, Bissot, Rigoulot, & Campanella, 2012). Using a single-cue design, we have shown that socially anxious individuals display an enhanced P1 in response to facial stimuli, together with an enhanced P2 component. As that occipital component has been associated with sustained perceptual processing (Schupp, Junghofer, Weike, & Hamm, 2003; Schupp et al., 2004) and the mobilization of attentional resources on salient stimuli to process (Eldar, Yankelevitch, Lamy, & Bar-Haim, 2010), we interpreted that last effect as reflecting an attention anchorage by facial information possibly responsible for further difficulty in disengagement (Rossignol and Philippot et al., 2012). Conversely, social anxiety does not influence the N170, reflecting the encoding of the structural characteristics of facial stimuli (Eimer & Holmes, 2007), when participants have to detect emotional expressions amongst a set of neutral faces (Rossignol and Campanella et al., 2012) or identify the expression or the colored background of angry, happy and neutral faces in an emotional Stroop paradigm (Peschard, Philippot, Joassin, & Rossignol, 2013). These data suggest that configural processing of human faces is not influenced by early attentional movements and takes place normally in subclinical SAnD (Kolassa et al., 2009; Peschard et al., 2013; Rossignol and Campanella et al., 2012).

Unfortunately, studies having explored the electrophysiological correlates of emotion biases in SAnD remain rare. Clearly, more data is needed to specify the cognitive mechanisms involved in these biases. In particular, the components of attention involved should be considered, by distinguishing between facilitated attention, difficulty in disengagement, and attentional avoidance (Cisler & Koster, 2010). In that context, the present study aimed to explore the influence of social anxiety on attentional capture by facial cues. We used a variant of the dot-probe task (MacLeod et al., 1986) to probe several emotions presented in pairs, together with a neutral counterpart. We intended to observe the neural responses to three types of negative expressions: anger and fear, since these expressions have been shown to be particularly relevant in social anxiety (for a review, see Staugaard, 2010), and disgust, since some data suggest a particular role of that emotion in the etiology and the maintenance of social anxiety (Amir et al., 2005). The direct comparison of these different negative expressions could allow highlighting the more salient threat in fear of negative evaluation. We also used happy faces, to provide a positive control.

After a short presentation of 200 ms, a single arrow, appearing on the former location of one of the two faces, had to be discriminated as quickly as possible by the participants. When the target appears at the location previously occupied by the emotional stimulus, the trial is valid and a faster detection is expected than for invalid targets cued by neutral faces (Brosch, Sander, Pourtois, & Scherer, 2008; Pourtois et al., 2004). If anxious participants are hypervigilant to threat, they should display a hypervigilance bias reflected by higher P1 amplitude in response to negative facial cues, as observed in SAnD participants (Mueller et al., 2009). An attention capture by these cues would evoke enhanced P2 amplitudes, in particular for pairs involving threatening (angry or disgusted) faces. The assessment of the P1 in response to the probe allows differentiation between an enhanced vigilance toward threat-cued location, observable through enhanced amplitude for these targets as reported in trait-anxiety (Li et al., 2005), and avoidance as observed in social phobia with reduced P1 amplitudes for targets cued by threatening faces (Mueller et al., 2009). Finally, if hypervigilance acts on late stages of cognitive processing, SAnD participants should react faster to the probe replacing negative emotional faces than to the probe replacing neutral faces (Mogg & Bradley, 2002).

2. Materials and methods

2.1. Participants

Thirty right-handed participants (age range: 18–24), with normal/corrected vision and without neurological disease, were selected from a sample of 250 university students screened using the Fear of Negative Evaluation Scale (FNE, Watson & Friend, 1969). That inventory is a measure of cognitive symptoms of social anxiety, in such a way that it determines the degree to which individuals experience apprehension to be negatively evaluated (Musa, Kostogianni, & Lepine, 2004). The presence of social anxiety was detected through a score above 19 on the FNE scale (Douilliez & Philippot, 2003; Philippot & Douilliez, 2005). Moreover, trait anxiety and depression features were also controlled: All participants had to score under 56 on the Spielberger Trait Anxiety Inventory (STAI, Spielberger, Gorsuch, & Lusthene, 1983) and under 9 to the 13-items Beck Inventory (Beck & Beck, 1972) to limit the comorbid symptomatology. Considering those criteria, we selected the 15 participants with the lowest scores and the 15 participants with the highest scores on the FNE scale to constitute the low social anxiety group (LSA) and the high social anxiety group (HSA). Four participants were excluded because of artefacts during ERP recording, so that 26 participants remained in the sample (see Table 1).

According to the standards of inventories, FNE scores of HSA reach those reported in SAnD patients, while LSA scored in the average (Musa et al., 2004); both groups obtained normal scores on STAIS and STAIT (Spielberger et al., 1983), and low scores of depression (Beck & Beck, 1972). Statistical analyses confirmed that HSA scored higher than LSA on measurements of social anxiety but not on state anxiety, trait anxiety, depression level and age (see Table 1).

2.2. Stimuli

The stimuli set comprised 30 black and white pictures of six different individuals (3 males and 3 females) each posing neutrality, anger, disgust, happiness and fear, taken from the Karolinska Directed Emotional Faces (KDEF, Lundqvist, Flykt, & Öhman, 1998). Adobe Photoshop software was used to exclude non-facial contours and hair and resized to be enclosed within a oval frame measuring 4 × 6 cm, subtending a visual angle of 2.5o × 3.8o. Facial displays were made up of two photographs of the same actor, presented at equal distance on the left and the right part of the screen. There were four different types of face pairs: neutral–angry, neutral–happy, neutral–disgust and neutral–fear and the position of the emotional faces (on the left or the right side of the screen) was equivalent within each block.

The target stimulus was a white arrow pointing up or down, sizing 2 cm (visual angle of 1.2o), presented against a black background at the location of the emotional face (valid trial, 60%), or the neutral face (invalid trial, 40%). The percentage of valid trials was chosen to be consistent with paradigms used by Bar-Haim et al. (2007) and studies using ERP recording (Perchet, Revol, Fourneret, Mauguière, & Garcia-Larrea, 2001). Probe type and spatial position (left or right) were counterbalanced through the task.

2.3. Procedure

All stimuli were presented on a black background on a 17-in. computer Dell Inspiron with the software EEProbe. As shown in Fig. 1, each trial started with a 2 × 2 cm fixation cross appearing in the centre of the screen for 200 ms, followed by a delay (black screen) of 200 ms and then replaced by the display of the face pairs for 500 ms. 200 ms after their disappearance, the probe was presented for 200 ms. The probe could either replace the emotional or the neutral face, with a set validity of 60–40 (valid/invalid). A blank screen was then displayed as an inter-trials interval, lasting for 1000 ms. Six blocks were created, each containing 80 trials. Participants were asked to press one of two response buttons to indicate the orientation of the arrow (“up” or “down”), and they were told that speed was important but not at the cost of accuracy.

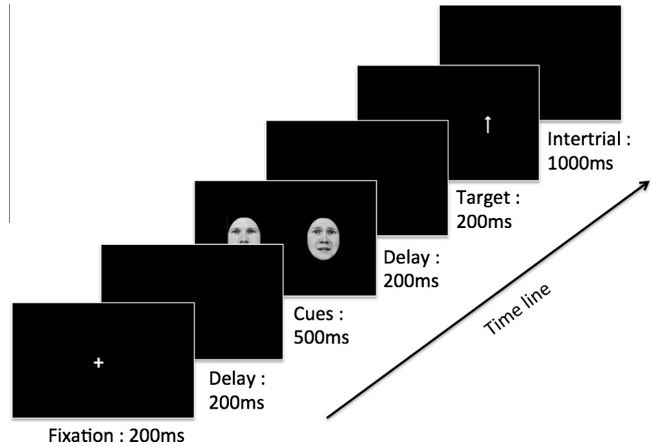

Fig. 1. Sequence of the events in the spatial cueing task.

At the beginning of the session, participants completed the Spielberger State Anxiety Inventory (Spielberger et al., 1983). Then, they sat in a dark room on a chair placed at 90 cm from the screen with their head restrained in a chin rest. Before starting the task, practice trials familiarized participants with the procedure. Then, they were presented with the 12 blocks (6 blocks repeated twice) of 80 trials (the entire experiment consisted of 960 trials), with a pseudo-randomized presentation of the different types of emotional cues within each block). They were tested individually in a single-session lasting approximately 1 h.

Different measures were recorded to assess behavioral performance. The presentation software recorded reaction times and accuracy to each target presentation. We computed the percentage of correct responses (errors could be an erroneous response, an absence of response within the given time, or a response occurring before target presentation or less than 200 ms after its onset) and averaged RT for correct responses.

2.4. EEG data acquisition

The EEG recordings were performed with 32 electrodes mounted in an electrode Quick-Cap with the standard 10–20 International System and intermediate positions. Recordings were made with a linked mastoid physical reference and were re-referenced by using a common average (Bertrand, Perrin, & Pernier, 1985). The EEG was amplified by battery-operated A.N.T.® amplifiers with a gain of 30,000 and a band-pass of 0.01–100 Hz. The impedance of all electrodes was kept below 5 kΩ. The EEG was recorded continuously (sampling rate 512 Hz, A.N.T. EEProbe software) and trials containing EOG artifacts (mean of 10%) were eliminated off-line by computing an average artefact response based on a percentage of the maximum eye movement potential. Epochs beginning 100 ms prior to stimulus onset and continuing for 700 ms were created. Codes synchronized with stimulus delivery were used to selectively average the epochs associated with different stimulus types. ERPs were averaged separately for the different combination of experimental variables: emotion (neutral and angry, fearful, happy, or disgusted face), Visual Field of

Table 1
Means and standard deviation of characteristics and self-reported measures of anxiety and depression for participants with social anxiety and healthy controls.

	LSA (n = 13)	HSA (n = 13)	t and p values
Age (years)	22.6 (2.8)	21.2 (1.7)	$t(24) = 1.571$, NS
Ratio male/female	4/9	2/11	$X^2 = .867$, NS
FNE	8.7 (1.6)	23.6 (3.4)	$t(24) = 14.302$, $p < .001$
STAI-A	47.5 (6.8)	49.7 (4.9)	$t(24) = .953$, NS
STAI-B	45.5 (4.4)	48.9 (4.2)	$t(24) = 1.486$, NS
Beck	1.9 (2.2)	3.4 (2.6)	$t(24) = 1.565$, NS

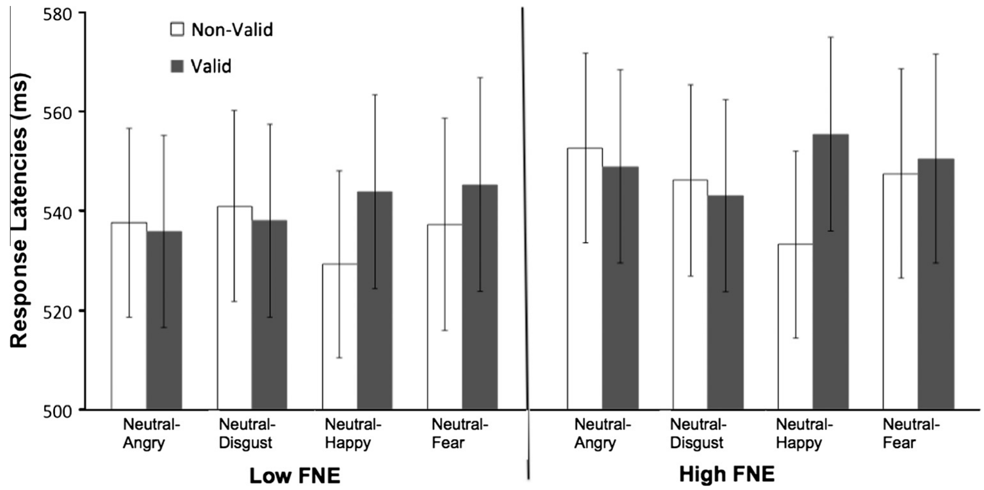

Fig. 2. Mean response time (RTs) and standard error bars for targets replacing neutral (non-valid) and emotional (valid) cues for the low and the high FNE groups.

presentation of the emotional face (left or right) and target validity (valid tor invalid).

2.5. ERP analyses

Following an inspection of the grand mean ERP's and in accordance with recent literature about electrophysiological correlates of spatial attention (Eldar et al., 2010; Mueller et al., 2009), ERP analyses focused on the mean amplitudes of the P1, the N170, and the P2 elicited by the face pairs (see Fig. 3) and the P1 evoked by the probe (Fig. 4). The P1-face and P1-probe mean amplitudes were respectively computed between 100–160 and 100–200 ms after stimulus presentation at O1 and O2. The N170 mean amplitude was averaged between 160–240 ms at P7 and P8 and the P2 at 240–400 ms at O1 and O2 after face pair presentation.

2.6. Statistical analysis

Statistical analyses were computed using the Statistical Package for Social Sciences, 17th version (spss 17.0). Mean response times were submitted to a $2 \times 4 \times 2 \times 2$ ANOVA with Validity (valid, invalid), Emotion (angry–neutral, fear–neutral, disgust–neutral and happy–neutral face pairs), and Visual Field (LVF, RVF) as within-subject factors and FNE (High, Low) as the between-subject factor. For ERPs evoked by facial display (P1, N170 and P2), the mean amplitude averaged across the selected electrode sites was subjected to a similar $4 \times 2 \times 2 \times 2$ ANOVA with Emotion (angry–neutral, fear–neutral, disgust–neutral and happy–neutral face pairs), Visual Field (LVF–RVF) and Hemisphere (left, right) as within-subject factors, and FNE (High, Low) as the between-subject factor. Finally, for the P1 evoked by the targets, we computed a $2 \times 4 \times 2 \times 2 \times 2$ ANOVA by adding the Validity factor (valid, invalid) to the model described above. All results reported are Greenhouse-Geisser corrected. Simple effects were explored throughout and the Bonferroni post hoc test for multiple comparisons was used to compare mean scores within the different conditions when decomposing significant interactions. The alpha level of significance was set at 0.05 throughout.[1]

[1] Since gender has been shown to influence emotional processing and ERPs parameters (Campanella et al., 2004), we performed the same analyses by including the Gender as between-subjets variable. Main and interaction effects involving Gender were not significant and were not reported here.

3. Results

3.1. Behavioral RT data

We calculated the accuracy and the mean RT for correct responses during the ERP recording. As a ceiling effect was observed in accuracy (performances varied from 93% to 98%), analyses focused on response latencies (see Fig. 2).

Analysis revealed a main effect of validity, $F(1,24) = 11.399$, $p = .001$, $\eta_p^2 = .322$ indicating faster responses for invalid trials (541 vs. 545 ms). Moreover, an interaction between validity and emotion, $F(3,72) = 10.393$, $p < .001$, $\eta_p^2 = .302$, indicated a differential influence of emotion in valid and invalid trials. To explain this interaction, separate ANOVA were conducted in valid and invalid conditions. In the invalid condition, a main emotion effect, $F(3,75) = 8.023$, $p < .001$, $\eta_p^2 = .251$, showed that probes following neutral faces in neutral–happy pairs were detected more quickly than those following neutral–angry ($p < .001$), disgust ($p = .004$) or fear ($p = .008$), without differences between these latter conditions. In the valid condition, the emotion effect, $F(3,75)$=3.893, $p = .012$, $\eta_p^2 = .140$, revealed a longer reaction time after neutral–happy pairs as compared to neutral-disgust ($p = .013$). Indeed, the paired t-test showed that probes following neutral–happy pairs were detected more quickly in the invalid condition, $t(25) = 6.215$, $p = <.001$, while validity did not significantly affect the reaction time in the other conditions.

Finally, a main effect of Visual Field, $F(1,24) = 10.767$, $p = .003$, $\eta_p^2 = .310$ indicated faster response latencies when emotional faces where located on the LVF (540 ms) as compared to the RVF (545 ms).

FNE did not significantly affect response latencies ($F(1,24) = .098$, N.S.).

3.2. P1 to face-pairs onset

A main effect of FNE, $F(1,24) = 5.068$, $p = .03$, $\eta_p^2 = .174$, indicated higher amplitudes in High (1.86 μV) as compared to Low FNE (0.74 μV) (see Fig. 3).

Moreover, a significant interaction between Emotion $\times$ Hemisphere $\times$ FNE, $F(3,72) = 2.703$, $p = .05$, $\eta_p^2 = .101$ was decomposed further by computing separated ANOVA in each groups. These analyses showed an interaction between Emotion and Hemisphere in Low FNE, $F(3,36) = 3.369$, $p = .03$, $\eta_p^2 = .219$ with higher amplitude on the left hemisphere, particularly for pairs involving Disgust

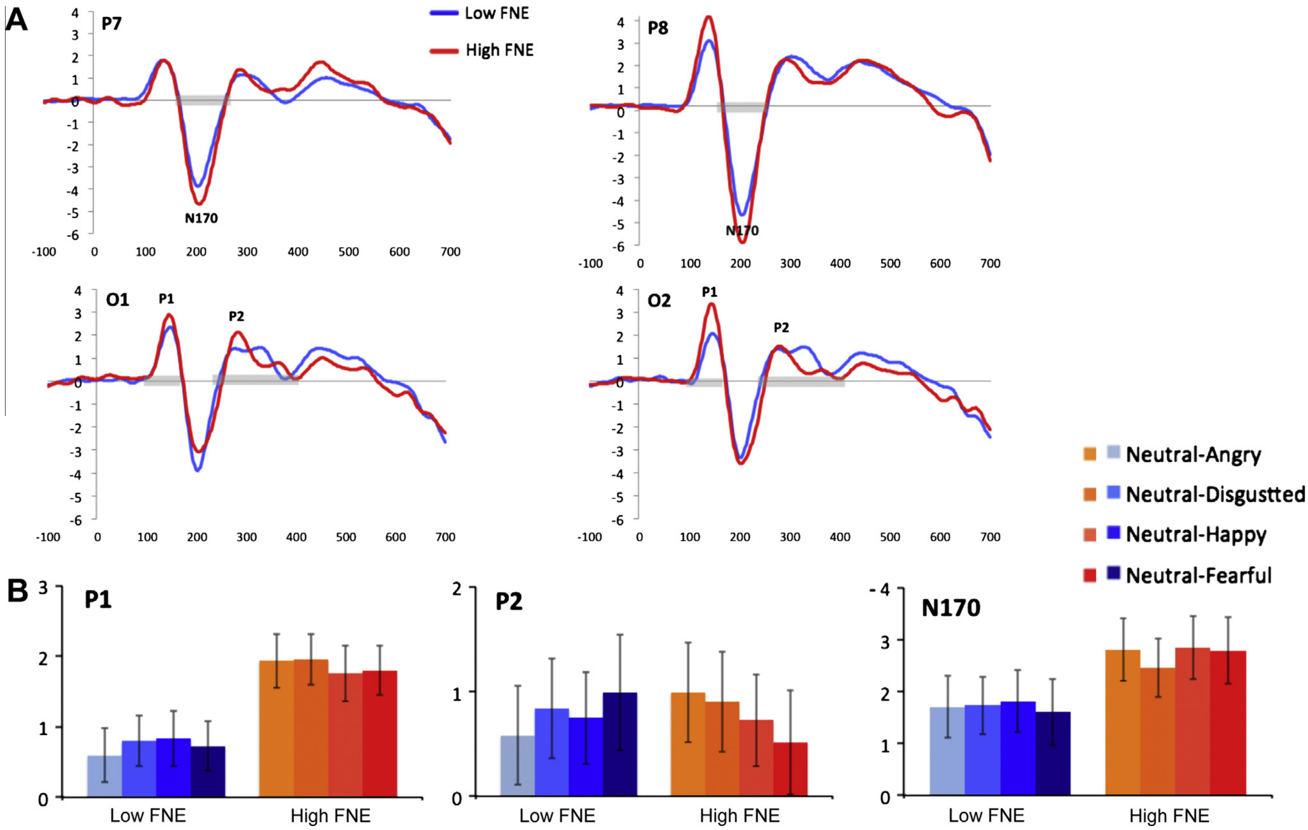

Fig. 3. (A) Waveforms of P1, N170, P2 in response to facial cues in high FNE (red lines) and low FNE (blue lines) groups. (B) Mean amplitudes of P1, P2 and N170 as a function of face pairs and groups.

and Fear. High FNE did not show such modulation of their P1 response by Emotion and Hemisphere.

3.3. N170 to face-pairs onset

A main effect of Visual Field was marginally significant, $F(1,24) = 3.752$, $p = .06$, $\eta_p^2 = .135$, and suggested higher N170 amplitudes when the emotional faces occupied the right location as compared to the left one (−2.49 vs. −2.36 μV). Additionally, a significant interaction between Visual Field and Hemisphere, $F(1,24) = 4.859$, $p = .037$, $\eta_p^2 = .168$ suggested enhanced N170 on the left hemisphere when the right Visual Field was occupied by the emotional face, but no particular differences on the left hemisphere.

Other factors did not influence the N170 amplitudes.

3.4. P2 to face-pairs onset

Main factors did not influence the P2 amplitude, but an interaction between FNE and Emotion reached significance, $F(3,72) = 2.692$, $p = .05$, $\eta_p^2 = .101$ and was decomposed further. Emotion did not modulate P2 amplitude in Low FNE, $F(3,36) = 1.124$, N.S., but High FNE showed enhanced amplitudes for neutral–anger as compared to neutral–fear pairs ($p = .037$) and the Emotion effect was marginally significant, $F(3,72) = 2.39$, $p = .08$, $\eta_p^2 = .136$.

3.5. P1 to target onset

The analyses returned a main effect of Validity, $F(1,24) = 5.69$, $p = .031$, $\eta_p^2 = .179$ with enhanced amplitudes for Valid trials (2.3 μV as compared to 2.1 for Invalid trials, see Fig. 4).

However, these effects were further qualified by a Validity × Emotion, $F(3,72) = 2.885$, $p = .05$, $\eta_p^2 = .107$. That interaction indicated higher P1 amplitudes for valid targets in neutral–fear, neutral–anger and neutral–happy pairs, but enhanced responses for invalid targets in neutral–disgust pairs.

Moreover, a FNE × Validity interaction, $F(1,24) = 4.716$, $p = .04$, $\eta_p^2 = .164$ was broken down by examining High and Low FNE groups separately. No modulation of P1 amplitude by Validity was found in the Low FNE group, $F(1,12) = 005$, N.S. while the Validity effect was highly significant in High FNE, $F(1,12) = 12.364$, $p = .004$, $\eta_p^2 = .508$, and indicated enhanced P1 for target replacing an emotional face (2.2 μV) compared to a neutral face (1.94 μV).

Finally, a Validity × Visual Field × Hemisphere, $F(1,24) = 23.842$, $p < .001$, $\eta_p^2 = .498$, logically indicated enhanced contralateral P1 amplitudes (i.e., on the left hemisphere for a target presented on the left hemifield).

4. Discussion

The present study used ERPs to index the cognitive processes involved in the emergence of attention biases in social anxiety. Participants reporting low or high fear of social evaluation were submitted to a modified dot-probe paradigm and had to detect neutral targets cued by pairs of neutral–emotional faces.

A major result concerns the general increase of the P1 component in response to pairs of faces in participants reporting high fear of negative evaluation. This effect was not influenced by the nature of facial expression involved in the pair, suggesting that the hypervigilance was generalized to all emotional faces. As our design did not include neutral–neutral pairs, it is not possible to verify whether this increased attention is related to the emotional load

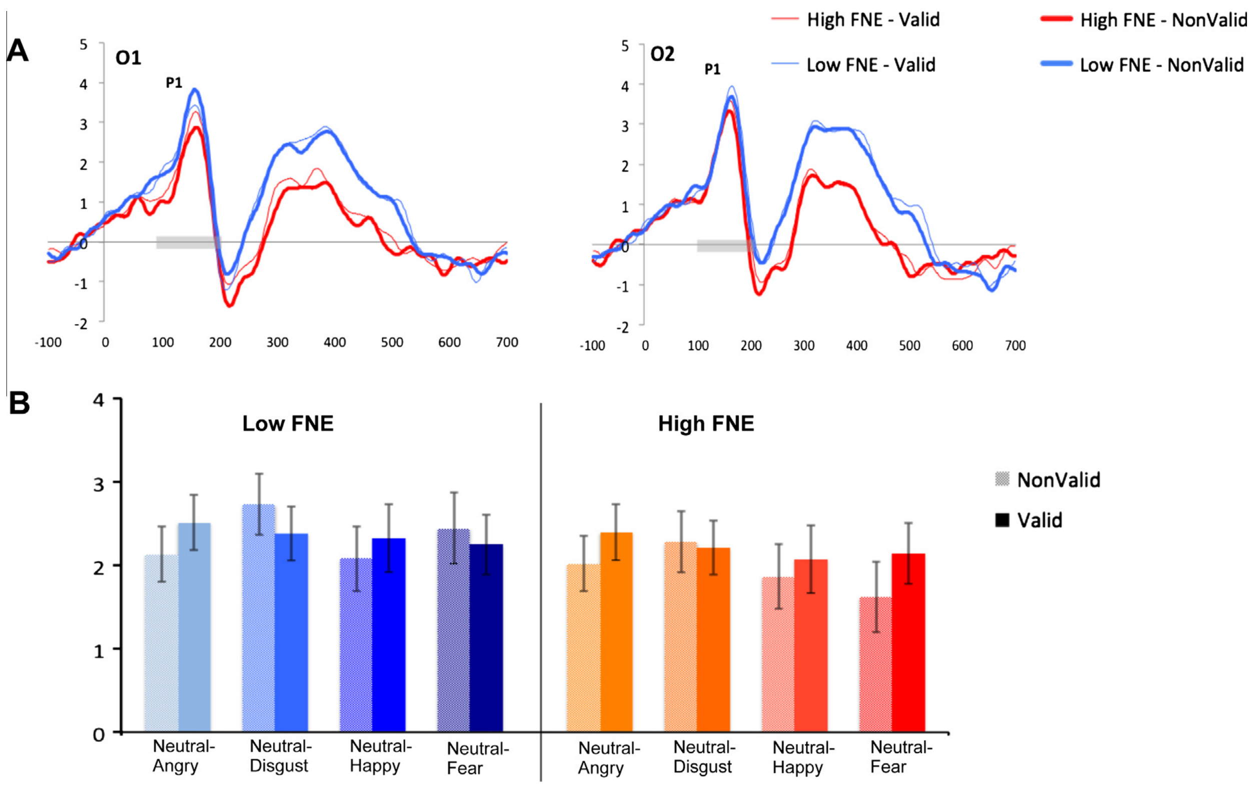

Fig. 4. (A) Waveforms of P1 to targets in high FNE (red lines) and low FNE (blue lines) groups. (B) Mean amplitudes of target-P1 as a function of validity, face pairs and groups.

of the stimuli or to a general higher arousal/activation level in SAnD participants. To address this question, further research should compare the neural responses to face vs. some other non-social stimulus. Indeed, the same phenomenon of increased P1 was recently reported for neutral faces in SAnD (Rossignol and Campanella et al., 2012; Rossignol and Philippot et al., 2012), and some authors have contended that human faces (even neutral ones) automatically capture attention in social anxiety (Yiend, 2010). Moreover, the P1 increase indicates an hyperactivation of cortical areas responsible for the perceptual processing of visual information, and it has been suggested that this cortical hyperresponsiveness may be a general characteristic of phobic states (Kolassa, Musial, Kolassa, & Miltner, 2006). These results are supported by recent findings showing enhanced P1 in response to colored rectangles presented as control stimuli in an emotional Stroop paradigm (Peschard et al., 2013). Finally, the P1 is also submitted to top-down influences from the parietal and frontal region (Foxe & Simpson, 2002), which have been described as being involved in emotional processing in SAnD (Bruhl et al., 2011). Indeed, patients with SAnD submitted to the anticipation of non-specific general emotional stimuli showed increased brain activity in the thalamus, the amygdala, the temporo-occipital and parietal regions, together with decreased activity in the left orbitofrontal cortex (Bruhl et al., 2011). In conclusion, SAnD was associated with enhanced activation in brain regions involved in emotional arousal as well as perception processing with diminished attention control. These results suggest a general disturbance of emotion processing in basic neural pathways in SAnD.

The effect of social anxiety was also observed on the P2 component. Indeed, high FNE participants showed increased P2 in response to neutral–anger as compared to neutral–fear pairs, while non-anxious subjects did not demonstrate this effect. The P2 has been relatively rarely studied in the literature on anxiety and attention (for a review, see Staugaard, 2010). That component has been functionally associated with the evaluation of the emotional relevance of a visual stimulus (Carretié, Martín-Loeches, Hinojosa, & Mercado, 2001; Dennis & Chen, 2007). It may also be enhanced by uncertainty, as shown by Kolassa et al. (2009) who reported an increase in the P2 amplitude when schematic faces were classified as neutral, as compared to happy, sad or angry. The emotional categorization could have been more difficult for these neutral faces and the P2 amplitude reflects the complexity of this emotional appraisal. Similarly, it was suggested that this component reflects the capture of attentional resources from stimuli being processed (Schupp et al., 2003, 2004). If one observes this functional hypothesis, the enhancement of this component, also evidenced in high trait anxiety (Bar-Haim, Lamy, & Glickman, 2005; Eldar et al., 2010), could mirror a greater mobilization of attentional resources on motivationally significant stimuli in social phobic participants. It would mean that angry faces are more salient than fearful faces in SAnD. These results may also be interpreted as increased difficulty in disengaging attention from these stimuli in evaluation anxiety.

In contrast, the N170 did not appear as sensitive to anxiety, nor to the emotional load of face pairs. The N170 reflects the encoding of the structural properties of facial stimuli (Bentin, Allison, Puce, Perez, & McCarthy, 1996) and modulations of this component in response to the presentation of pairs of faces have rarely been studied. The fact that two faces must be encoded simultaneously could reduce the sensitivity of this component to their emotional load. However, it should be noted that the impact of an emotional load on the N170 remains controversial in the literature, since some studies report an emotional effect (Batty & Taylor, 2003; Blau, Maurer, Tottenham, & McCandliss, 2007; Krombholz, Schaefer, & Boucsein, 2007; Rossignol, Philippot, Douilliez, Crommelinck, & Campanella, 2005) while others do not (Eimer & Holmes, 2002; Holmes et al., 2003). Similarly, social anxiety was associated with an increase in the N170 in response to angry faces in two studies

(Kolassa & Miltner, 2006; Wieser, Pauli, Reicherts, & Muhlberger, 2010), but several others did not replicate this effect, neither with an implicit emotional processing task (Muhlberger et al., 2009; Rossignola and Campanella et al., 2012), or with task requiring an explicit processing of the emotional load (Peschard et al., 2013). In that context, Peschard et al. (2013) conclude to a non-altered structural analysis of faces in individuals with subclinical SAnD.

Conversely, the cognitive response to targets was dependent on the level of anxiety. While non-anxious subjects showed no effect of validity, with similar responses to stimuli following neutral or emotional faces, high FNE participants showed an increase of the P1 for valid targets. In contrast to our hypothesis, which postulated an increased P1 for target cues by the angry faces only, this effect was observed for all validly-cued targets, demonstrating the maintenance of attentional resources on the location of emotional cues, and not only for negative or threatening cues. These results do not support the hypothesis of a secondary avoidance following the initial hypervigilance to cues. Indeed, Mangun and Hillyard (1996) have shown higher P1 amplitude when a target appeared in a cued location as compared to a non-cued location, meaning that selective attention could enhance visual processes. If the hypothesis of avoidance had been verified, we would have observed a reduced P1 for valid targets relative to invalid ones. In contrast, our results highlighted an initial hypervigilance to face pairs, followed by an higher attentional anchorage on the angry–neutral pairs, and a sustained attention to the location of emotional faces in all conditions.

Finally, response times were not modulated by the evaluation anxiety level but emotions act on response latencies. In invalid condition, participants were quickly to detect targets succeeding to a neutral face when its counterpart expressed happiness rather than disgust, anger or fear. It suggests a longer delay to move attention away from these negative emotions. Conversely, when the target follow the emotional faces, disgust leads to faster responses than happiness, which could mean that participants are less attentive to positive emotions, but anger and fear do not lead to faster detection of valid targets. The absence of negative bias in non-anxious individuals is consistent with the results in the general population (Bar-Haim et al., 2007). The behavioral expression of emotional biases in sub-clinical social anxious individuals is less consistent (for a review, see Staugaard, 2010). If some data suggested that sub-clinical social anxious individuals are prone to demonstrate the same bias as that observed in clinical populations (Mogg & Bradley, 2002; Moriya & Tanno, 2011), different recent studies did not evidence any behavioral difference between anxious and non-anxious individuals (Pineles & Mineka, 2005; Rossignol and Campanella et al., 2012; Rossignol and Philippot et al., 2012). Some methodological factors may account for these discrepancies. For instance, Moriya and Tanno (2011) reported that high and low FNE participants did not differ on a gap paradigm, allowing a gap between faces disappearance and target occurrence, while high FNE had longer RTs in response to angry faces when the task involved a synchronized presentation of cues and targets. This may argue for the absence of behavioral effects in the present study. However, the lack of behavioral effect should not make forget the presence of significant cognitive modulations in socially anxious participants. It highlights the ability of ERP to detect even subtle differences that are undetectable at a behavioral level (Olofsson, Nordin, Sequeira, & Polich, 2008). Our results are in line with the idea that anxiety may alter processing efficiency more than performance effectiveness (Eysenck, Derakshan, Santos, & Calvo, 2007). One may also hypothesized that early perceptual modulations may be characteristic of young individuals with moderate comorbidity (McTeague, Shumen, Wieser, Lang, & Keil, 2011; Rossignol and Campanella et al., 2012; Rossignol and Philippot et al., 2012) while more severe forms of social phobia may affect later processes and lead to significant behavioral impairments (Mueller et al., 2009).

The present study is amongst the firsts to provide cues of cognitive processes underlying attentional biases in anxiety. Behavioral studies have often tried to understand the temporal course of attentional biases by contrasting different times of presentation of stimuli. For example, Miskovic and Schmidt (2012) presented pairs of faces for 100, 500 or 1250 ms with the hypothesis of a variability of bias scores with the presentation time. While these experimental manipulations are of great interest, response latencies only provide indirect cues about the cognitive processes involved. Electrophysiology provides more tangible evidence of early attention and avoidance. Hence, the present results suggest that early attention may be indexed by an increase of the P1 component in response to facial cues, while an increased P2 may reflect an attentional anchorage by some cues. That enhanced attention capture may complicate the disengagement from these cues and/or facilitated the attentional engagement to the succeeding targets. Finally, the examination of the P1 in response to targets allows attention movements to be evaluated, since that component appears as enhanced for targets appearing at the attended location. These results also have important clinical applications, since they allow a better definition of the process to be targeted with retraining methods (Koster, Baert, Bockstaele, & De Raedt, 2010). Despite these interesting insights, the present study is not without limitations. Mainly, this research included a relatively small sample of participants, with a gender imbalance in high vs. low FNE groups. Whether the independence between participants' gender and group membership was established, future studies should better control that variable. Moreover, emotional results on behavioral data were not rigorously mirrored on the ERP components analyzed in the present study, which were chosen for their significance in anxiety states. However, at least two ERPs could have been relevant to explore these emotional effects, namely the early posterior negativity (EPN) and the late positive potential (LPP). These components are consistently modulated by emotional load (Lee & Park, 2011) but their modulation by social anxiety is quite unclear (Staugaard, 2010) and should be evaluated in further studies.

5. Conclusion

The main aim of the present study was to explore the cognitive processes responsible for attentional bias toward emotional information in relation to a low or high level of fear of negative evaluation, which is a major component of social anxiety. Our results show that high evaluation anxiety levels led to modulations of different stages of cognitive processing of information, namely on the P1 and P2 in response to cues, and on the P1 in response to targets. These results are interpreted as indexing facilitated attention to faces and sustained attention for emotional face location, and offer reliable cues to the cognitive processes involved in attention biases in social anxiety.

Author's note

Mandy Rossignol is a Postdoctoral Researcher and Salvatore Campanella is a Research Associate at the National Fund for Scientific Research (F.N.R.S., Belgium). The authors are grateful to Joffrey Goumet, Pierre Maurage and Luciana Falbo for their valuable help during data analyses.

References

Allison, T., Puce, A., Spencer, D. D., & McCarthy, G. (1999). Electrophysiological studies of human face perception. I: Potentials generated in occipitotemporal cortex by face and non-face stimuli. *Cerebral Cortex, 9*(5), 415–430.

Amir, N., Foa, E. B., & Coles, M. E. (1998). Automatic activation and strategic avoidance of threat-relevant information in social phobia. *Journal of Abnormal Psychology, 107*(2), 285–290.

Amir, N., Klumpp, H., Elias, J., Bedwell, J. S., Yanasak, N., & Miller, L. S. (2005). Increased activation of the anterior cingulate cortex during processing of disgust faces in individuals with social phobia. *Biological Psychiatry, 57*(9), 975–981.

Bar-Haim, Y., Lamy, D., & Glickman, S. (2005). Attentional bias in anxiety: A behavioral and ERP study. *Brain and Cognition, 59*(1), 11–22.

Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & van Ijzendoorn, M. H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: A meta-analytic study. *Psychological Bulletin, 133*(1), 1–24.

Batty, M., & Taylor, M. J. (2003). Early processing of the six basic facial emotional expressions. *Brain Research. Cognitive Brain Research, 17*(3), 613–620.

Beck, A. T., & Beck, R. W. (1972). Screening depressed patients in family practice: A rapid technique. *Postgraduated Medicine, 52*(6), 81–85.

Bentin, S., Allison, T., Puce, A., Perez, E., & McCarthy, G. (1996). Electrophysiological studies of face perception in humans. *Journal of Cognitive Neuroscience, 8*(6), 551–565.

Bertrand, O., Perrin, F., & Pernier, J. (1985). A theoretical justification of the average reference in topographic evoked potential studies. *Electroencephalography and Clinical Neurophysiology, 62*(6), 462–464.

Blau, V. C., Maurer, U., Tottenham, N., & McCandliss, B. D. (2007). The face-specific N170 component is modulated by emotional facial expression. *Behavioral and Brain Functions, 3*(7).

Bögels, S. M., & Mansell, W. (2004). Attention processes in the maintenance and treatment of social phobia: Hypervigilance, avoidance, and self-focused attention. *Clinical Psychology Review, 24*, 827–856.

Brosch, T., Sander, D., Pourtois, G., & Scherer, K. R. (2008). Beyond fear: Rapid spatial orienting toward positive emotional stimuli. *Psychological Science, 19*(4), 362–370.

Bruhl, A. B., Rufer, M., Delsignore, A., Kaffenberger, T., Jancke, L., & Herwig, U. (2011). Neural correlates of altered general emotion processing in social anxiety disorder. *Brain Research, 1378*, 72–83.

Campanella, S., Rossignol, M., Mejias, S., Joassin, F., Maurage, P., Debatisse, D., et al. (2004). Human gender differences in an emotional visual oddball task: An event-related potentials study. *Neuroscience Letters, 367*(1), 14–18.

Carretié, L., Martín-Loeches, M., Hinojosa, J. A., & Mercado, F. (2001). Emotion and attention interaction studied through event-related potentials. *Journal of Cognitive Neuroscience, 13*(8), 1109–1128.

Chen, Y. P., Ehlers, A., Clark, D. M., & Mansell, W. (2002). Patients with generalized social phobia direct their attention away from faces. *Behaviour Research and Therapy, 40*(6), 677–687.

Cisler, J. M., & Koster, E. H. (2010). Mechanisms of attentional biases towards threat in anxiety disorders: An integrative review. *Clinical Psychology Review, 30*(2), 203–216.

Clark, D. M. (1999). Anxiety disorders: Why they persist and how to treat them. *Behaviour Research and Therapy, 37*(Suppl. 1), S5–27.

Clark, D. M., & Wells, A. (1995). A cognitive model of social phobia. In R. G. Heimberg, M. R. Liebowitz, D. A. Hope, & R. Schneider (Eds.). *Social phobia: Diagnosis, assessment and treatment* (pp. 69–93). New York: Guilford.

Dennis, T. A., & Chen, C. C. (2007). Neurophysiological mechanisms in the emotional modulation of attention: The interplay between threat sensitivity and attentional control. *Biological Psychology, 76*(1–2), 1–10.

Douilliez, C., & Philippot, P. (2003). Biais dans l'évaluation volontaire de stimuli verbaux et nonverbaux: Effet de l'anxiété sociale. *Revue Francophone de Clinique Comportementale et Cognitive, 8*, 12–18.

Eimer, M., & Holmes, A. (2002). An ERP study on the time course of emotional face processing. *NeuroReport, 13*(4), 427–431.

Eimer, M., & Holmes, A. (2007). Event-related brain potential correlates of emotional face processing. *Neuropsychologia, 45*(1), 15–31.

Eldar, S., Yankelevitch, R., Lamy, D., & Bar-Haim, Y. (2010). Enhanced neural reactivity and selective attention to threat in anxiety. *Biological Psychology*.

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion, 7*(2), 336–353.

Fox, E., Derakshan, N., & Shoker, L. (2008). Trait anxiety modulates the electrophysiological indices of rapid spatial orienting towards angry faces. *NeuroReport, 19*(3), 259–263.

Fox, E., Russo, R., & Dutton, K. (2002). Attentional bias for threat: Evidence for delayed disengagement from emotional faces. *Cognition and Emotion, 16*, 355–379.

Foxe, J. J., & Simpson, G. V. (2002). Flow of activation from V1 to frontal cortex in humans. A framework for defining "early" visual processing. *Experimental Brain Research. Experimentelle Hirnforschung. Experimentation Cerebrale, 142*(1), 139–150.

Frewen, P. A., Dozois, D. J., Joanisse, M. F., & Neufeld, R. W. (2008). Selective attention to threat versus reward: Meta-analysis and neural-network modeling of the dot-probe task. *Clinical Psychology Review, 28*(2), 307–337.

Hillyard, S. A., & Anllo-Vento, L. (1998). Event-related brain potentials in the study of visual selective attention. *Proceedings of the National Academy of Sciences of the United States of America, 95*(3), 781–787.

Holmes, A., Vuilleumier, P., & Eimer, M. (2003). The processing of emotional facial expression is gated by spatial attention: Evidence from event-related brain potentials. *Brain Research. Cognitive Brain Research, 16*(2), 174–184.

Klumpp, H., & Amir, N. (2009). Examination of vigilance and disengagement of threat in social anxiety with a probe detection task. *Anxiety, Stress & Coping, 22*(3), 283–296.

Kolassa, I. T., Kolassa, S., Bergmann, S., Lauche, R., Dilger, S., Miltner, W. H. R., et al. (2009). Interpretive bias in social phobia: An ERP study with morphed emotional schematic faces. *Cognition & Emotion, 23*(1), 69–95.

Kolassa, I. T., & Miltner, W. H. (2006). Psychophysiological correlates of face processing in social phobia. *Brain Research, 1118*(1), 130–141.

Kolassa, I. T., Musial, F., Kolassa, S., & Miltner, W. H. (2006). Event-related potentials when identifying or color-naming threatening schematic stimuli in spider phobic and non-phobic individuals. *BMC Psychiatry, 6*, 38.

Koster, E. H., Baert, S., Bockstaele, M., & De Raedt, R. (2010). Attentional retraining procedures: Manipulating early or late components of attentional bias? *Emotion, 10*(2), 230–236.

Krombholz, A., Schaefer, F., & Boucsein, W. (2007). Modification of N170 by different emotional expression of schematic faces. *Biological Psychology, 76*(3), 156–162.

Lee, S. - H., & Park, G. - H., 2011. Psychophysiological Markers of Anxiety Disorders and Anxiety Symptoms.

Li, X., Li, X., & Luo, Y. J. (2005). Anxiety and attentional bias for threat: An event-related potential study. *NeuroReport, 16*(13), 1501–1505.

Luck, S. J., Hillyard, S. A., Mouloua, M., & Hawkins, H. L. (1996). Mechanisms of visual-spatial attention: Resource allocation or uncertainty reduction? *Journal of Experimental Psychology: Human Perception and Performance, 22*(3), 725–737.

Lundqvist, D., Flykt, A., & Öhman, A. (1998). *The karolinska directed emotional faces – KDEF*. Stockholm: Karolinska Institutet.

MacLeod, C., Mathews, A., & Tata, P. (1986). Attentional bias in emotional disorders. *Journal of Abnormal Psychology, 95*(1), 15–20.

Mangun, G. R., & Hillyard, S. A. (1996). Selective attention: Mechanisms and models. In M. D. Rugg & M. G. H. Coles (Eds.), *Electrophysiology of mind: Event-related brain potentials and cognition*. Oxford: Oxford Psychology Press.

Mansell, W., Clark, D. M., Ehlers, A., & Chen, Y. P. (1999). Social anxiety and attention away from emotional faces. *Cognition & Emotion, 13*(6), 673–690.

McTeague, L. M., Shumen, J. R., Wieser, M. J., Lang, P. J., & Keil, A. (2011). Social vision: Sustained perceptual enhancement of affective facial cues in social anxiety. *Neuroimage, 54*(2), 1615–1624.

Miskovic, V., & Schmidt, L. A. (2012). Early information processing biases in social anxiety. *Cognition & Emotion, 26*(1), 176–185.

Mogg, K., & Bradley, B. P. (2002). Selective orienting of attention to masked threat faces in social anxiety. *Behaviour Research and Therapy, 40*(12), 1403–1414.

Mogg, K., Philippot, P., & Bradley, B. P. (2004). Selective attention to angry faces in clinical social phobia. *Journal of Abnormal Psychology, 113*(1), 160–165.

Moriya, J., & Tanno, Y. (2011). The time course of attentional disengagement from angry faces in social anxiety. *Journal of Behavior Therapy and Experimental Psychiatry, 42*(1), 122–128.

Mueller, E. M., Hofmann, S. G., Santesso, D. L., Meuret, A. E., Bitran, S., & Pizzagalli, D. A. (2009). Electrophysiological evidence of attentional biases in social anxiety disorder. *Psychological Medicine, 39*(7), 1141–1152.

Muhlberger, A., Wieser, M. J., Herrmann, M. J., Weyers, P., Troger, C., & Pauli, P. (2009). Early cortical processing of natural and artificial emotional faces differs between lower and higher socially anxious persons. *Journal of Neural Transmission, 116*(6), 735–746.

Musa, C., Kostogianni, N., & Lepine, J. P. (2004). The fear of negative evaluation scale (FNE): Psychometric properties of the French version.. *Encephale, 30*(6), 517–524.

Olofsson, J. K., Nordin, S., Sequeira, H., & Polich, J. (2008). Affective picture processing: An integrative review of ERP findings. *Biological Psychology, 77*(3), 247–265.

Perchet, C., Revol, O., Fourneret, P., Mauguière, F., & Garcia-Larrea, L. (2001). Attention shifts and anticipatory mechanisms in hyperactive children: An ERP study using the Posner paradigm. *Biological Psychiatry, 50*(1), 44–57.

Peschard, V., Philippot, P., Joassin, F., & Rossignol, M. (2013). The impact of the stimulus features and task instructions on facial processing in social anxiety: An ERP investigation. *Biological Psychology, 93*(1), 88–96.

Philippot, P., & Douilliez, C. (2005). Social phobics do not misinterpret facial expression of emotion. *Behaviour Research and Therapy, 43*(5), 639–652.

Pineles, S. L., & Mineka, S. (2005). Attentional biases to internal and external sources of potential threat in social anxiety. *Journal of Abnormal Psychology, 114*(2), 314–318.

Pishyar, R., Harris, L. M., & Menzies, R. G. (2008). Responsiveness of measures of attentional bias to clinical change in social phobia. *Cognition and Emotion, 22*(7), 1209–1227.

Posner, M. I., Snyder, C. R. R., & Davidson, B. J. (1980). Attention and the detection of signals. *Journal of Experimental Psychology: General, 109*, 160–174.

Pourtois, G., Grandjean, D., Sander, D., & Vuilleumier, P. (2004). Electrophysiological correlates of rapid spatial orienting towards fearful faces. *Cerebral Cortex, 14*(6), 619–633.

Rapee, R. M., & Heimberg, R. G. (1997). A cognitive-behavioral model of anxiety in social phobia. *Behaviour Research and Therapy, 35*(8), 741–756.

Rossignol, M., Campanella, S., Maurage, P., Heeren, A., Falbo, L., & Philippot, P. (2012). Enhanced perceptual responses during visual processing of facial stimuli in young socially anxious individuals. *Neuroscience Letters, 526*(1), 68–73.

Rossignol, M., Philippot, P., Bissot, C., Rigoulot, S., & Campanella, S. (2012). Electrophysiological correlates of enhanced perceptual processes and attentional capture by emotional faces in social anxiety. *Brain Research, 1460*, 50–62.

Rossignol, M., Philippot, P., Douilliez, C., Crommelinck, M., & Campanella, S. (2005). The perception of fearful and happy facial expression is modulated by anxiety: An event-related potential study. *Neuroscience Letters, 377*(2), 115–120.

Salemink, E., van den Hout, M. A., & Kindt, M. (2007). Selective attention and threat: Quick orienting versus slow disengagement and two versions of the dot probe task. *Behaviour Research and Therapy, 45*(3), 607–615.

Santesso, D. L., Meuret, A. E., Hofmann, S. G., Mueller, E. M., Ratner, K. G., Roesch, E. B., et al. (2008). Electrophysiological correlates of spatial orienting towards angry faces: A source localization study. *Neuropsychologia, 46*(5), 1338–1348.

Schupp, H. T., Junghofer, M., Weike, A. I., & Hamm, A. O. (2003). Attention and emotion: An ERP analysis of facilitated emotional stimulus processing. *NeuroReport, 14*(8), 1107–1110.

Schupp, H. T., Öhman, A., Junghofer, M., Weike, A. I., Stockburger, J., & Hamm, A. O. (2004). The facilitated processing of threatening faces: An ERP analysis. *Emotion, 4*(2), 189–200.

Spielberger, C. D., Gorsuch, R. L., & Lusthene, R. E. (1983). *Manual for the state-trait anxiety inventory*. Palo Alto.: Consulting Psychologist Press.

Staugaard, S. R. (2010). Threatening faces and social anxiety: A literature review. *Clinical Psychology Review, 30*(6), 669–690.

Taylor, J. G., & Fragopanagos, N. F. (2005). The interaction of attention and emotion. *Neural Networks, 18*(4), 353–369.

Telzer, E. H., Mogg, K., Bradley, B. P., Mai, X., Ernst, M., Pine, D. S., et al. (2008). Relationship between trait anxiety, prefrontal cortex, and attention bias to angry faces in children and adolescents. *Biological Psychology*.

Vassilipoulos, S. P. (2005). Social anxiety and the vigilance-avoidance pattern of attentional processing. *Behavioral and Cognitive Psychotherapy, 33*, 13–24.

Vuilleumier, P. (2005). How brains beware: Neural mechanisms of emotional attention. *Trends in Cognitive Sciences, 9*(12), 585–594.

Watson, D., & Friend, R. (1969). Measurement of social evaluative anxiety. *Journal of Consulting and Clinical Psychology, 33*, 448–457.

Wieser, M. J., Pauli, P., Reicherts, P., & Muhlberger, A. (2010). Don't look at me in anger! Enhanced processing of angry faces in anticipation of public speaking. *Psychophysiology, 47*(2), 271–280.

Yiend, J. (2010). The effects of emotion on attention: A review of attentional processing of emotional information. *Cognition & Emotion, 24*(1), 3–47.