SOCIALLY ANXIOUS INDIVIDUALS PERFORM BETTER USING LOW SPATIAL FREQUENCY INFORMATION TO PROCESS FACIAL EXPRESSIONS AND OBJECTS

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Abstract

Abstract Background and objectives: It is well known that socially anxious individuals show biased processing towards threatening faces and better performance with low spatial frequencies information (LSF). It is unclear whether this bias is confined to facial processing or can be extended to other types of information. Methods: Two experimental phases involving discrimination tasks considering neutral and angry facial expressions and everyday objects in two different spatial frequency conditions were conducted to compare the performance of “socially and non-socially anxious individuals”. Results: Findings showed that highly socially anxious individuals (HSAi) were faster in decision processing

for LSF neutral faces than LSF angry faces and responded more slowly to LSF angry faces than unfiltered angry faces. Moreover, they responded more quickly to LSF object images than low socially anxious individuals (LSAi). Limitations: The fact that the participants were not diagnosed with social anxiety disorder limits the relevance of clinical findings. The study is further limited because it compared and contrasted only two emotional expressions and two frequency bands. Conclusions: Study results showed that HSAi better process LSF neutral information and that this advantage is not limited to neutral faces alone, but extends across other domains.

1 INTRODUCTION

Social anxiety is defined as an excessive and persistent fear elicited by one or more social situations in which an individual is exposed to possible scrutiny and judgement by others (American Psychiatric Association, 2013; World Health Organization, 1992). According to some cognitive models of social anxiety, dysfunctional beliefs and fear of being judged elicit stronger vigilance towards sources of supposed social threat and ultimately lead to heightened anxiety and to maintain the disorder (Beck & Emery, 1985; Clark & Wells, 1995; Rapee & Heimberg, 1997).

Despite some inconsistencies in the findings (see Bantin, Stevens, Gerlach, & Hermann, 2016), theoretical models have stressed the importance of such information-processing biases in maintaining high levels of social anxiety and in highlighting the role of attentional bias towards the environment (hypervigilance) and, in particular, towards threatening stimuli (e.g., Pergamin-Hight, Naim, Bakermans-Kranenburg, van Ijzendoorn, & Bar-Haim, 2015). For example, within the vigilance-avoidance model (see Mogg & Bradley, 1998) the avoidance of emotional stimuli results from the operations of idiosyncratic schemas that direct attentional resources while processing (specific) threatening information. Others (e.g., Eysenk & Calvo, 1992) postulate dysfunctions in the attentional control mechanism that – when presented with threat-related information – recruits excessive attentional resources and experiences difficulties in disengaging from the stimulus. Both models hypothesize a late or early avoiding process of the threatening stimuli that would maintain the disorder.

Cognitive information-processing biases related to the control and allocation of attentional resources in social anxiety have been investigated by means of, among others, Stroop tasks, Dot-Probe tasks, and face recognition tasks. Evidence shows that in the Stroop task the content of social threat words – such as *public*, *criticized* – interferes with the ability of socially anxious individuals to name the colour of these stimuli, suggesting that socially anxious individuals are automatically engaged by threat-related words (see, among others, Hope, Rapee, Heimberg, & Dombeck, 1990 and Maidenberg, Chen, Craske, Bohn, & Bystritsky, 1996). The results of the studies with the Dot-Probe task have proven less conclusive: while some studies show enhanced vigilance towards angry faces in anxious individuals vs. non-anxious controls (e.g., Asmusdon & Stein, 1994; Klumpp & Amir 2009), others either fail to find such effect (e.g., Pineles & Mineka, 2005) or show the reverse effect, e.g., avoidance of emotional faces (e.g., Mansell, Clark, Ehlers & Chen, 1999; Chen, Ehlers, Clark & Mansell, 2002). With respect to face recognition tasks, results have proven that socially anxious individuals show an enhanced recognition of negative facial expressions if compared with positive ones (Lundh & Öst, 1996; Foa et al., 2000), and that recognition accuracy is particularly enhanced for angry faces (Gilboa-Schechtman, Foa, & Amir, 1999). Taken together, these findings suggest that

– in individuals with social anxiety - there is an excessive automatic engagement with items related to social threat and are consistent with the notion that there is a functional hypervigilance towards sources of social threat.

A further bias connected with social anxiety emerges when socially anxious individuals are asked to visually scan faces: typically, they avoid eye contact, e.g., they explore the eyes and the area around the eyes less extensively than non-anxious control. This bias has been reported both in clinical observations (Greist, 1995; Ohman, 1986) and in experimental studies (Horley, Williams, Gonsalvez, & Gordon, 2004; Schneier, Rodenbaugh, Blanco, Lewin, & Liebowitz, 2011). Horley et al. (2004) showed that socially anxious individuals tend to avoid scanning the area around the eyes when looking at images of faces, especially when the images depict angry faces. Along with eye contact avoidance, Schneier et al. (2011) showed that eye contact itself may trigger social anxiety. Thus, the avoidance of eye contact in social anxiety may represent a defensive strategy for coping with a hypervigilance to perceive threat in social situations. This account of eye contact avoidance in social anxiety can be situated within the vigilance-avoidance hypothesis (Beck & Clark, 1997) which proposes that hypervigilance is associated with early, automatic processing, while avoidance reflects late, strategic allocation of attentional resources (see Chen & Clarke, 2017).

In a social interaction, avoidance of eye contact potentially leads socially anxious individuals to miss relevant contextual information. Thus, it might be that in order to avoid missing relevant information about facial expressions, socially anxious individuals take advantage of the visual information that is projected to the areas devoted to peripheral vision: put it another way, the idea here is that while social anxious individuals are not looking directly into the eyes or the area around the eyes of their interlocutors, they are nevertheless processing the eyes or the area around using peripheral vision. However, peripheral vision is relatively poor, in the sense that the visual image is less detailed: peripheral vision takes place through the processing of low spatial frequencies. Different Spatial Frequencies (SFs) - defined as the number of cycles per degree of visual angle and/or the number of cycles per image -seem to have distinctive impacts on face recognition (Langner, Becker, Rinck, & van Knippenberg, 2015; Schyns & Oliva, 1999; Smith & Schyns, 2009): Low SFs (LSFs) mimic the information detected at a great distance or during the night and seem to account for emotional faces and emotions detection (Langner et al., 2015) while High (and medium) SFs (HSFs) are dedicated to the recognition of facial identity and gender (e.g., Calder, Lawrence, & Young, 2001; Morrison & Schyns, 2001; Schyns, Bonnar, & Gosselin, 2002). LSFs information and threat detection seem to be associated with the amygdala activity (e.g., Vuilleumier, Armony, Driver, & Dolan, 2003) through a subcortical pathway (LeDoux 2000) that has numerous connections with the visual and orbitofrontal cortex (Schyns, Petro, & Smith, 2009). It is therefore possible for anxious individuals to use LSFs as a way of processing information preferentially. Moreover, if socially anxious individuals utilize peripheral vision to examine facial expressions, they might learn or prefer to process facial expressions information at LSF information differently from unanxious counterparts. A series of studies provided marked evidence in face processing advantage in social anxiety (Langner, Becker, & Rinck, 2009; Langner, Becker, & Rinck, 2012; Langner et al., 2015). Specifically, Langner et al. (2015) compared the performance of High (HSAi) and Low Social Anxiety Individuals (LSAi) in processing four different frequency bands while scrutinizing angry or neutral facial expressions. In all conditions anxious individuals were faster, and were also advantaged in processing low spatial information *tout-court*, regardless of the type of emotion shown by the facial expression.

A part of the current study was dedicated to the replication of these findings. HSAi and LSAi were exposed to low spatial filtered and unfiltered face images. We expected to find that the HSAi were faster in identifying faces filtered than their low anxiety counterparts. In addition, we compared neutral and angry expressions.

We wondered if the HSAi' advantage in processing faces at LSFs results from a specific mechanism linked to processing faces and facial expressions; in other words, if it was the consequence of a characteristic way used by socially anxious individuals to interact with others – e.g., by avoiding eye contact – it may be argued that the function that could benefit would be the one 'trained' for that task (e.g., the one directly involved in the task). Alternatively, the advantage might rely on a more general mechanism of processing LSFs information: if this were the case, then the advantage of socially anxious individuals in processing low spatial frequency information might not be limited to faces alone but could extend to everyday objects. To test this last hypothesis, we presented high and low socially anxious individuals with low spatial filtered and unfiltered images of ordinary objects. We hypothesized that if the advantage extends to other objects, the HSAi should process low spatial frequency images of objects more efficiently than low socially anxious individuals, with no differences between the two groups for unfiltered visual objects.

2 EXPERIMENT

2.1 METHOD

Participants. A total of 493 undergraduate students enrolled at the University of Padua and the Civic School of Performing Arts of Milan were considered candidates for recruitment. This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethical Committee of the Department of General Psychology, University of Padua. All completed the following questionnaires:

The Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996; the Italian version of the questionnaire was developed by Ghisi, Flebus, Montano, Sanavio, & Sica, 2006) is a 21-item, multiple-choice, self-report scale assessing the severity of affective and cognitive features of depression. The BDI-II has excellent reliability and validity and is widely used in clinical research. The Italian version of the BDI-II showed good internal consistency ($\alpha = .80$) and a 30-day retest reliability of .76, as well as good convergent, divergent, and criterion validity (Ghisi et al., 2006). Our sample maintained a good internal consistency ($\alpha = .81$).

The Beck Anxiety Inventory (BAI; Beck, Epstein, Brown, & Steer, 1988; Beck & Steer, 1990; the Italian version was developed by Coradeschi et al., 2007; Sica & Ghisi, 2007) is a 21-item self-report inventory used to measure physiological and cognitive anxiety symptoms. The original version of the BAI showed good internal consistency ($\alpha = .92$). The Italian version indicated good internal consistency ($\alpha = .80$) and a 30-day test-retest reliability of .62. In our sample, we noticed good internal consistency of BAI ($\alpha = .79$).

The Fears Inventory (FI; Sanavio, 1985) is the Italian adaptation of the Fear Survey Schedule (Wolpe & Lang, 1964), which is composed of 58 items, is divided into 5 sub-scales: “Calamity”, “Criticism and Social Rejection”, “Repulsive Animals”, “Trips and Activities Away from Home”, and “Blood and Health Fears”. The “Criticism and Social Rejection” sub-scale concerns situations in which an individual might experience fear about other people’s judgement. The “Repulsive Animal” sub-scale concerns fear of non-dangerous animals that are nevertheless traditionally or culturally considered repulsive and associated to gloomy natural habitats. Each item in the schedule receives a score on a 5-point Likert scale, ranging from 0 (not at all) to 4 (very much). This test showed both good internal consistency (total score: $.95 < \alpha < .97$; sub-scales: $.78 < \alpha < .92$) and temporal stability respectively at 7 ($r = .85$) and 30 days (total score: $r = .89$; sub-scales: $.73 < \alpha < .89$). In the present research the FI has been used substantially for three main reasons: it’s an Italian adapted inventory based on a large sample (Sanavio, Bertolotti, Michielin, Vidotto, & Zotti, 1997), it investigates fear reactions to social criticism and rejection, and it permits to evaluate different specific fears.

Subjects with clinical levels of depression, assessed using the BDI-II (cut-off scores major of 17 for males and major or equal to 19 for females corresponding to the 95° percentile; Beck, et al., 1996, Ghisi et al., 2006) or anxiety measured by the BAI (cut-off score major to 18 corresponding to the 90° percentile; Beck, & Steer, 1993; Sica, Coradeschi, Ghisi, & Sanavio, 2006) or fear of animals, as gauged by the “Repulsive Animal” sub-scale of the Fear Inventory (cut-off scores major or equal to 15 for males and major or equal to 24 for females corresponding approximately to the 90° percentile) were excluded from the study in order to control confounding effects of clinical symptoms, such as depression and anxiety, and to prevent the inclusion of individuals with animal phobia in HSAi or LSAi groups (Sanavio et al., 1997).

Sixty-two individuals were enrolled (N = 16 males; 26.2%, age range = 19 and 31 years; mean age=22.50, SD=2.39). The thirty-one scoring above or equal to the 90° percentile of the "Social Criticism" sub-scale of the Fear Inventory (e.g., with a raw score above or equal to 42 for the females and above or equal to 39 for the males) formed the HSAi group. The thirty-one participants scoring below or equal to the 10° percentile (e.g., with a raw score inferior or equal to 19 for the females and inferior or equal to 14 for the males) of that sub-scale constituted the LSAi group. The subjects' demographic data are outlined in Table 1.

Table 1 about here

Design. The experiments were designed to examine functional processing differences between high and low socially anxious individuals in recognizing unfiltered or low-pass filtered versions of two types of images:

1) Facial expressions: the study employed a 2x2x2 factorial design to consider two types of facial expressions (angry vs. neutral) and two types of spatial frequencies (LSFs vs. unfiltered) as the within-subject variables and two groups (HSAi vs. LSAi) as the between-subjects variable. The task consisted in deciding if the expression was angry or neutral.

2) Ordinary, everyday objects: the study employed a 2x2 factorial design to consider two types of images (LSFs vs. unfiltered) as the within-subject variable and two groups (HSAi vs. LSAi) as the between-subjects variable. The task was to decide if the image depicted an animal or an object. Reaction Times (RTs) and accuracy were the dependent variables.

Material. For the first task, the target stimuli consisted in 124 grayscale pictures of adult Caucasian faces (50% males) from the Karolinska Directed Emotional Faces Database (KDEF; Lundwvist, Flykt, & Öhman, 1998) reflecting different emotions. Half of the faces presented angry expressions; the other half presented neutral ones. The size of the face pictures measuring 562 x 762 pixels. (Figure 1)

Figure 1 about here

For the second task, a total of 96 pictures of ordinary, everyday objects were selected as the target stimuli. A total of 54 pictures of animals were used as filler stimuli. The pictures, which were grayscale drawings on a white background, were scaled to fill a 256 x 256 pixels square and had a resolution of 75 pixels per inch.

A low spatial filtered version (6 cycles per image) of all of the pictures (the objects/animals and the faces) was created (see Bar et al., 2006). Each picture was presented twice to each of the participants, once with low spatial frequency filtering and once unfiltered. The practice block was made up of twenty-four pictures of faces and other thirteen images (eight objects and five animals). For each of the practice items a low spatial filtered version was created. The tasks were counterbalanced across the participants.

Apparatus and procedure. The stimuli were presented on a 17-in. LCD monitor with 1920x1080 pixel resolution and 60Hz refresh rate. The data were collected via E-Prime (Psychology Software Tools Inc.) running on an IBM compatible computer connected to a video graphics (VGA) monitor. The distance between the monitor and participants was 60 cm. For the facial expression task, the participants were asked to press one button on the keyboard if the stimulus depicted an angry face and another button if the stimulus depicted a neutral one. For the object decision task, the participants were asked to press one button on the keyboard if the stimulus was an animal and another button if the stimulus depicted an object. The assignment of buttons to conditions was counterbalanced across participants.

The participants were instructed to respond as quickly and as accurately as possible. The 248 faces and 300 objects/animals (1/2 LSFs and 1/2 unfiltered) were presented in a random order to each of the participants. The LSFs and unfiltered pictures were presented within the same block of stimuli and randomly intermixed.

Each trial involved the following: a fixation cross appeared in the centre of the screen for 500ms and followed by a blank interval lasting 110ms. An image appeared and remained visible until the participant responded or 4 seconds elapsed. The inter-trial interval was set to 1200ms.

Figure 2 about here

2.2 RESULTS

Statistical analysis. To investigate the internal consistency of each self-report questionnaire, a Cronbach's alpha was performed. Moreover, to examine functional processing differences between HSAi and LSAi in recognizing unfiltered/low-pass filtered versions of faces and animal/objects a repeated measures ANOVA and post-hoc with Bonferroni correction were used. Finally, to investigate differences between the two groups regarding the self-report questionnaire scores and some demographic variables an Independent Samples t Test was performed.

Facial Expressions

RTs. Errors (4.6%) were excluded prior to the analysis of the RTs. A main effect was found considering LSFs and unfiltered faces: $F(1,56) = 4.10$, $p = .04$, $\eta 2p = .06$. A significant interaction between the facial expression and the type of spatial frequency was found, $F(1, 56) = 6.44$, $p < .05$, $\eta 2p = .10$, as well as between the kind of expression, the type of spatial frequency and social anxiety $F(1, 56) = 4.71$, $p = .034$, $\eta 2p = .078$. The means and standard deviations of the RTs are outlined in Table 2.

As demonstrated by a post-hoc ANOVA, this last interaction is explained by a significant interaction, $F(1,30) = 8.43$, $p = .007$, $\eta 2p = .22$, between the Facial Expression and the Spatial Frequency (Figure 3) for the HSAi group. On the basis of the within group analysis the HSAi were found to be faster for the neutral faces than for the angry ones in the LSFs condition, $F(1,30) = 7.12$, $p = .012$, $\eta 2p = .19$. The HSAi were also found to be faster in the unfiltered rather than in the LSFs condition for the angry faces, $F(1,30) = 9.79$, $p = .004$, $\eta 2p = .25$ (Figure 3). Moreover, on the basis of the within group LSAi, subjects were found to be faster for unfiltered than LSFs faces: $F(1, 27) = 4.79$, $p = .038$, $\eta 2p = .15$). No other main effects or interactions were found.

Table 2 and Fig.3 about here

Accuracy. A main effect for spatial frequency was found, $F(1,58) = 336.45$, $p < 0.001$, $\eta 2p = 0.85$ (Table 3). The unfiltered pictures were identified more accurately than those in the LSFs condition. Another main effect was the type of facial expression, $F(1,58) = 53.806$, $p = < 0.001$: as angry faces were identified less accurately than neutral expressions. No between group differences were found. A post-hoc analysis within the HSAi and LSAi groups revealed respectively that they were both more accurate $F(1,30) = 28.75$, $p < 0.001$ $\eta 2p = 0.49$ (Table 3); $F(1, 28) = 15.03$, $p < 0.001$, $\eta 2p = 0.34$, for the neutral rather than for the angry faces in the LSFs condition.

Table 3 about here

Objects

RTs. Errors were excluded prior to RTs analysis. The main effect of spatial frequency proved significant, $F(1,60) = 83.1$, $p < 0.001$, $\eta 2p = .58$. The main effect of group was not significant, $F(1, 60) = 2.3$, $p = .132$, $\eta 2p = .03$. The interaction between the two variables proved significant, $F(1, 60) = 4.7$, $p < .05$, $\eta 2p = .07$, reflecting the fact that the HSAi responded more quickly to the LSFs images (M = 592.8; DS = 109.47) than the LSAi did (M = 660.3; DS = 136.4) (Figure 4).

Figure 4 about here

Accuracy. A significant main effect of spatial frequency was found, $F(1,60) = 9.8$, $p < .005$; $\eta 2p = 0.14$. Unfiltered objects (M = .97, SD = .29) were identified more accurately than LSFs images (M = .91, SD = .08). No other significant effects were found, all Fs < 1.

3 DISCUSSION

The aim of the study was twofold: first, to determine if the advantage of HSAi over LSAi controls in processing LSFs facial expressions is modulated by the emotional content of those expressions; second, to examine if the advantage of HSAi - with respect to LSAi controls - in processing LSFs facial extends to images of common, everyday objects. To this aim, we presented – in two distinct but counterbalanced blocks – unfiltered and LSFs images of angry or neutral faces and unfiltered and LSFs images of everyday objects to a group of HSAi and to a group of LSAi. Participants had to discriminate either angry from neutral facial expression or images of objects from images of animals.

An analysis of the RTs for the facial expressions showed a significant three-way interaction among the types of expressions (angry vs. neutral), spatial frequencies (unfiltered vs. LSFs), and social anxiety (HSAi vs. LSAi). Post-hoc within-group analyses revealed that the three-way interaction is due to the following reasons: it took longer for LSAi participants took longer to classify LSFs faces than unfiltered faces irrespectively from the kind of facial expression, e.g., LSAi showed a main effect of spatial frequencies only. On the contrary, while HSAi classified LSFs angry expressions more slowly than unfiltered angry expressions, they classified LSFs neutral expression both as quickly as unfiltered neutral expressions and more quickly than LSFs angry expressions. Thus, if we consider the two groups independently, we note how HSAi showed a specific advantage in processing LSFs neutral faces with respect to LSFs angry faces, an advantage that the LSAi participants did not show.

Our results confirm those reported by Langner et al. (2015) and take them a few steps forward: while previous research showed that HSAi do indeed process efficiently LSFs-filtered images of faces, our study shows that this efficiency is modulated by the kind of facial expression that is being processed - namely, neutral vs. angry. However, it is important to point out that the way Langner et al. (2015) and our research group presented the stimuli could explain the divergences in the obtained results: while in the former study the stimuli were presented for 200ms, in our study the stimuli remained on the screen for up to a maximum of 4 sec, thus allowing to HSAi more time to process and evaluate the expressions, and it is therefore possible that, because of this, our stimuli generated more vivid representations, thus allowing the specificity of neutral and angry faces to distinctively affect performance.

As far as everyday objects are concerned, an analysis of RTs showed a significant interaction between LSFs (unfiltered vs. LSFs) and social anxiety (HSAi vs. LSAi). The interaction is due to the fact that although both HSAi and LSAi individuals process LSFs images more slowly than unfiltered images, the effect is significantly larger for LSAi than for HSAi. The finding leads us to the conclusion that the relative advantage in processing LSFs images that the HSAi show is not limited to neutral faces, but extends to other domains. Given our results and regardless of the reasons that lead HSAi to manifest such a relative advantage, the mechanism involved is more likely to correspond to a general domain and not tied to face processing only.

It could be argued that the diminished cost associated with the processing of LSFs images of both neutral faces and everyday objects that is shown by HSAi (compared to the cost shown by LSAi) is due to the fact that HSAi have more experience with LSFs information than LSAi: HSAi tend to avoid eye contact and to look at the centre of the interlocutor's face, away from their interlocutor's eyes, and they are therefore forced to interpret degraded visual images of a part of the face projected onto the peripheral retina (Horley et al. 2004). Such an account would also predict that the enhanced experience with LSFs should extend its effects to any kind of facial expression and that, therefore, a diminished cost should have been observed in the processing of LSFs angry expressions as well, which we did not find. A possible solution to this puzzle might be that of ascribing the increase in RTs that the HSAi show in processing LSFs angry faces to a late process. We propose that HSAi experience more difficulty in disengaging attention from LSFs angry faces (Eysenck & Calvo, 1992): e.g., LSFs angry faces constitute a particularly challenging stimulus for HSAi. Our analysis of accuracy shows that LSFs images of faces are more difficult to classify than unfiltered images of faces, and that images of angry expressions are more difficult to classify than neutral expressions. Thus, LSFs angry expressions were particularly challenging for our participants: we argue that they were specifically difficult to process for our HSAi and that this specific difficulty showed up on RTs but not on accuracy.

Put it as resulting from a more significant experience with LSFs due to biases in exploring the environment, the advantage shown by HSAi can be seen as merely epiphenomenal. However, the performance advantage we found is still seen as a possible risk factor for the maintenance of the anxiety disorder. It might be, for example, that being (relatively) better at processing LSFs information does not motivate making eye contact. Additionally, although the rough configurational information provided by LSFs are central to the fast and accurate emotion identification (see, Schyns, Bonnar, & Gosselin, 2002), high spatial frequency does play a role in emotion recognition: Ekman & Friesen (1976) reported that small local cues (corresponding to HSFs) support explicit categorization of emotions. By mainly relying on peripheral vision and LSFs information to process the eyes and the area around them, HSAs might miss some relevant emotional cues and this might result in loose emotion classifications: such uncertainty might contribute to the maintenance of high levels of anxiety.

Our account for the smaller cost shown by HSAi (with respect to LSAi) in processing LSFs images of everyday objects and neutral faces vs. unfiltered images of everyday objects and neutral faces find some support in neuroimaging studies of anxiety disorders which have demonstrated that there is greater activation of the amygdala when socially anxious individuals are presented with emotional faces (Stein, Goldin, Sereen, Eyler Zorrilla, & Brown, 2002; Phan, Fitzgerald, Nathan, & Tancer, 2006), during speech anticipation (Lorberbaum et al., 2004) or criticism (Blair et al., 2008). Moreover, abnormal activations within the orbitofrontal or ventromedial prefrontal cortex (PFC) have been noted in individuals experiencing either clinical (see, McClure et al., 2007; Labuschagne et al., 2012) or high but non-clinical (Stein, Simmons, Feinstein, & Paulus, 2007) levels of social anxiety. Congruent with the role of the PFC in evaluating a threat, it has been demonstrated that the orbital PFC responds selectively to images of angry faces, but not to sad or neutral ones, and this activation is proportional to the magnitude of the anger the faces express (Blair, Morris, Frith, Perrett, & Dolan, 1999). Similarly, although the amygdala responds to angry LSFs facial expressions, it is substantially blind to HSFs facial expressions (Vuilleumier, Armony, Driver, & Dolan, 2003). Thus, the amygdala and the PFC form a dyad that constitutes the core of a system generating balanced cognitive/affective evaluations of the surrounding environment. This dyadic system seems to be biased towards excitatory, positive, hyper-responsive reactions in individuals experiencing high social anxiety, and both the PFC and the amygdala are sensitive to LSFs visual information (Chaumon, Kveraga, Feldman Barrett, & Bar, 2014; Vuilleumier & Pourtois, 2007). The PFC-amygdala system provides a mechanism to explain the diminished cost that HSAi (compared to LSAi) showed in processing LSFs images of everyday objects and neutral faces. It is therefore possible to ascribe the slowed response to LSFs images of angry faces to a late, attentional-decisional stage.

In this regard, it would therefore be interesting to investigate whether other individuals with phobic disorders use this information analysis system. For example, if animal phobic individuals respond faster to neutral LSFs information than specific threatening information (Öhman, Flykt, & Esteves, 2001; Lipp & Waters, 2007) one could hypothesize that this is strictly linked to anxiety disorders.

3.1 LIMITS OF THE STUDY AND FUTURE DIRECTIONS

Future investigations will seek to evaluate individuals who have been clinically diagnosed with social anxiety. Furthermore, our results may have been influenced by a greater frequency of the female gender. Given that social anxiety disorder is distributed equally or predominantly among women and they also show more arousal responses to threat (McLean, Asnaami, Litz, & Hofman, 2011; Bocanegra & Zeeelenberg, 2009), future studies should control these and all potential confounders.

Other investigations should, moreover, assess the effects of other emotional expressions in different spatial frequency bands in order to clarify the effects of neutral faces (compared to angry ones). If faces showing other emotions are included in the trials, this would confirm the validity of the conclusion that angry faces affect RTs and accuracy results because of their threatening valence and not because of their “emotional” significance.

Finally, combined neuroimaging and eye-tracking techniques may clarify the importance of central and peripheral processes in the analysis of spatial frequencies and emotional valence since the analysis that the visual system carries out and the activation of the involved cortical or subcortical areas could be concurrently observed.

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