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Attachment style impacts behavior and early oculomotor response to positive, but not negative, pictures

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The present study investigated whether oculomotor behavior is influenced by attachment styles. The Relationship Scales Questionnaire was used to assess attachment styles of forty-eight voluntary university students and to classify them into attachment groups (secure, preoccupied, fearful, and dismissing). Eye-tracking was recorded while participants engaged in a 3-seconds free visual exploration of stimuli presenting either a positive or a negative picture together with a neutral picture, all depicting social interactions. The task consisted in identifying whether the two pictures depicted the same emotion. Results showed that the processing of negative pictures was impermeable to attachment style, while the processing of positive pictures was significantly influenced by individual differences in insecure attachment. The groups highly avoidant regarding to attachment (dismissing and fearful) showed reduced accuracy, suggesting a higher threshold for recognizing positive emotions compared to the secure group. The groups with higher attachment anxiety (preoccupied and fearful) showed differences in automatic capture of attention, in particular an increased delay preceding the first fixation to a picture of positive emotional valence. Despite lenient statistical thresholds induced by the limited sample size of some groups ($p < 0.05$ uncorrected for multiple comparisons), the current findings suggest that the processing of positive emotions is affected by attachment styles. These results are discussed within a broader evolutionary framework.

Key words: Emotion, attention, insecure attachment style, social cognition, eye-tracking.

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INTRODUCTION

Attention, the selection of the features of the incoming sensory information to be processed, encompasses two intertwined processes: exogenous processes describe the rapid and automatic capture of attention by salient stimuli (Posner, 1980); endogenous processes describe the voluntary control of the sensory feature attended (Driver, 2011). Emotions are known to significantly, but independently, influence both attentional processes (Vuilleumier, Armony & Dolan, 2003). Since Darwin's (1872/1965) seminal work, emotions have been regarded as adaptive responses to either obstacles or opportunities that increase the likelihood that members of a given species endure and reproduce (e.g., Cosmides & Tooby, 2000). Later, it has been suggested that positive and negative emotions have different effects on attention (e.g., Blair, Smith, Mitchell *et al.*, 2007), for example, stronger exogenous capture by schematic faces depicting negative, compared to positive affects (Eastwood, Smilek & Merikle, 2001). This could be due to their distinct phylogeny value. Negative affects would pertain to survival mechanisms (e.g., Öhman, Lundqvist & Esteves, 2001; Öhman & Mineka, 2001, 2003) and be evolutionary very ancient, while positive affects would pertain to social interactions and be relatively more recent (LeDoux, 2012). Thus, it is more likely for positively valenced stimuli to have a stronger impact on endogenous than on exogenous attentional processes.

Within this framework, studying how human attachment impacts the effect of positive and negative emotions on attentional processes is of great interest because attachment describes how individuals apprehend their social interactions. According to Bowlby's (1969/1982, 1973, 1980) attachment theory, human beings, akin to many other primate species, are innately predisposed to social life and to establish affective bonds. This motivation shapes infants' socio-emotional behavior to learn about and maintain proximity with a caregiver, who provides nutrition, protection and warmth, vital for survival (Bowlby, 1973; Landers & Sullivan, 2012). However, humans vary dramatically in their tendency to seek and accept comfort from others (Ainsworth, Blehar, Waters & Wall, 1978; Bowlby, 1969/1982). In adulthood, these variations are typically classified in four styles of attachment (Bartholomew & Horowitz, 1991): secure, preoccupied (anxious), dismissive-avoidant, and fearful-avoidant. People securely attached rely on trustful interactions with others and respond effectively to displays of emotion, which is not the case of insecure people (Bartholomew & Horowitz, 1991). Individuals highly anxious regarding attachment, who have a tendency to seek others' acceptance and closeness but at the same time fear rejection and abandonment, are classified as preoccupied. By contrast, those with an avoidant style, especially the dismissive-avoidants, are strongly independent and emotionally distant from others, minimizing their attachment needs. In turn, the fearful-avoidant style involves simultaneously proximity-seeking and avoidance of social interaction by fear of rejection (Bartholomew & Horowitz, 1991; Mikulincer & Shaver, 2003, 2007).

Accordingly, the theory predicts that these individual differences, in particular in insecure attachment, might distinctively bias emotion information processing, especially regarding the anxious and avoidant features: highly anxious individuals are assumed to be hypervigilant to emotional and social signals, while avoidants are assumed to inhibit attention from those cues (Mikulincer & Shaver, 2003, 2007). There are, however, inconsistent data in the literature. For example, a study investigating the implicit interference of emotional pictures on a recognition task showed a dichotomy; attachment anxiety style was associated with hypervigilance, while attachment avoidance style was associated with inhibition of attention to the same stimuli (Silva, Soares & Esteves, 2012). Yet, and contrary to these theoretical predictions, some studies indicated that both attachment anxiety and avoidance were related to averted attention away from threatening stimuli (respectively attachment-related words, Dewitte, Koster, De Houwer & Buysse, 2007, and angry faces, in Dewitte & De Houwer, 2008), whereas others reported early vigilance in the perception of positive and negative facial expressions for both anxious and avoidant attached individuals (Niedenthal, Brauer, Robin & Innes-Ker, 2002). Overall and despite inconsistencies, these findings suggest that insecure attachment impacts implicit attentional processing of stimuli with emotional valence. However, very few studies reported specific differences between the types of insecure attachment (but see Silva *et al*., 2012).

In the present study, we investigated, using eye-tracking, whether attachment style significantly impacted visual exploration of pictures depicting social interaction with different emotional valence (Santos, Chaminade, da Fonseca, Silva, Rosset & Deruelle, 2011). To our knowledge, no study has used an eye-tracking paradigm to investigate the impact of attachment style on perception of emotions in pictures. Measuring early orienting behavior using eye movements appears particularly suitable to investigate the exogenous attraction of attention by emotional stimuli. This technique provides an objective measure of attention orientation with natural stimuli (e.g., Calvo, Nummenmaa & Hyönä, 2008). When simultaneously presented with an emotional and a neutral picture, participants tend to look first and longer on the emotional picture (Calvo & Lang, 2004; Nummenmaa, Hyönä & Calvo, 2006), even when they are explicitly instructed to attend to the neutral picture (Nummenmaa *et al*., 2006). These results imply an exogenous modulation of eye movements by the emotional content of the images. Here we explored whether the attachment style of the individuals, would significantly impact the visual exploration of pictures depicting emotions. Theoretical predictions were that individual differences in insecure attachment should distinctively bias emotion processing: anxiously attached individuals were assumed to be hypervigilant to emotional and social signs, while those with avoidant tendencies were assumed to turn away from these signals. Although attachment theory does not make any specific prediction regarding the processing of positive cues, here we additionally addressed whether or not positive and negative emotions were impacted similarly.

METHODS

Participants

Participants with normal or corrected-to-normal vision, recruited via advertisements distributed through the Aix-Marseille University Campus were included in this study in exchange of monetary compensation (7 euros). The experiment adhered to the Declaration of Helsinki. Participants signed informed consent.

Adult attachment style of participants was assessed using The Relationship Scales Questionnaire (RSQ; Griffin & Bartholomew, 1994; French version, Guédeney, Fermanian & Bifulco, 2010). The RSQ is a 30-item self-report questionnaire in which participants are asked to rate the extent to which each statement (e.g., “I know that others will be there when I need them”) best describes their general orientations in relationships on five-point scales. The thirty-item *RSQ* is subdivided on four subscales from which the four attachment prototypes are derived: secure, preoccupied, fearful, and dismissing. Following Griffin and Bartholomew’s (1994) procedures, scores for each attachment prototype are derived by calculating the mean of the four or five items of each subscale representing each attachment prototype (five statements contribute to the secure and dismissing attachment prototypes and four statements contribute to the fearful and preoccupied attachment prototypes). These means are then transformed into standard scores (Z-scores). An individual will be classified has having the attachment prototype for which his Z-score was highest.

After exclusion of participants on the basis of eye-tracking data (see below), the final sample included 48 university students (27 woman, M_{age} = 26.6, SD = 6.6) distributed as follows: secure group (n = 15, 8 women and 7 men, M_{age} = 26.0, SD = 5.7), preoccupied group (n = 11, 7 women and 4 men, M_{age} = 24.2, SD = 3.6), fearful-avoidant group (n = 9, 4 women and 5 men, M_{age} = 26.1, SD = 6.8), and dismissing-avoidant group (n = 13, 8 women and 5 men M_{age} = 26.0, SD = 9.4). There were no significant difference in terms of age (one-way ANOVA p = 0.89), nor in terms of sex distribution [χ^2 (3, N = 48) = 0.95, p = 0.81] between the groups.

In order to assess their anxiety level, participants also completed the Liebowitz Social Anxiety Scale (*LSAS*; Liebowitz, 1987. French version; Lépine & Lellouch, 1995). Analysis of variance (one-way ANOVA) performed on the *LSAS* scores revealed a significant main effect of Group [F(3, 44) = 4.09, p < 0.01, η^2 = 0.22], indicating that the secure group (M = 14.87, SD = 6.51) had significantly lower scores when compared to the preoccupied (M = 23.00, SD = 12.14, p = 0.03) and the fearful (M = 27.78, SD = 11.50, p = 0.002), but not with the dismissing group (M = 18.69, SD = 7.47, p = 0.28). Preoccupied and fearful attached individuals scored similarly high (p = 0.26). Worth of note, *LSAS* scores were much below cut-off scores, not reaching pathological anxiety (M = 20.19, SD = 10.16, range 4–44 points).

Stimuli

The pictures used to create the stimuli for this experiment depicted either one individual, or several individuals involved in social interactions (see examples in Fig. 1). There were 10 negatively-laden, 10 positively-laden and 30 emotionally neutral pictures (social scenes depicting people involved in non-emotional interactions or in daily activities such as working or walking). Pictures were mostly taken from the International Affective Picture System (IAPS; Lang, Bradley & Cuthbert, 2001)[1] and were supplemented by similar pictures drawn from commercially available sources, carefully selected in a pilot study.[2] Analysis of variance (ANOVA) was performed on valence and arousal ratings obtained from the self-assessment Manikin scales (SAM; Bradley & Lang, 1994). Analyses of valence ratings showed a significant effect of emotion [F(2, 37) = 525.22, p < 0.001]: negative (M = 2.05, SD = 0.26), positive (M = 7.21, SD = 0.37) and neutral pictures (M = 4.98; SD = 0.39).

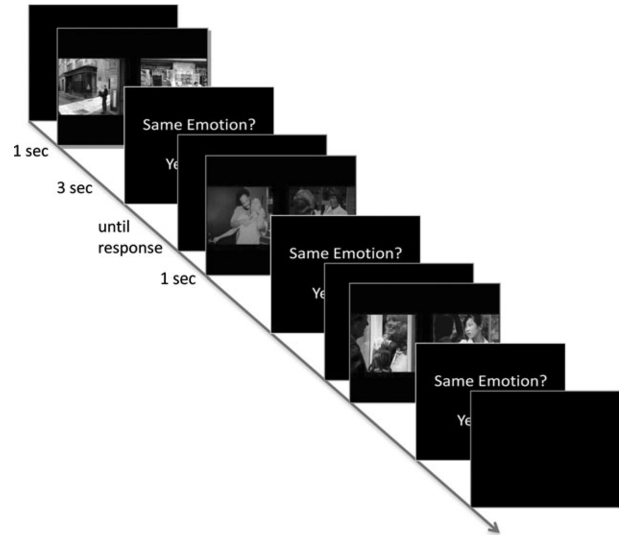

Fig. 1. Illustration of an experimental trial: each trial started with the presentation of a fixation cross (1 s), followed by the stimulus (3 s) and a response screen requiring participants to judge whether the same or different emotions were presented in the two pictures of the stimuli. Illustrated are examples of neutral (top), negative (middle) and of positive (bottom) stimuli.

Bonferroni-corrected multiple post hoc comparisons yielded differences between the three categories (all ps < 0.001). The same analysis for arousal ratings of negative (M = 5.88, SD = 0.92), positive (M = 5.21, SD = 0.89), and neutral pictures (M = 4.11, SD = 1.09), revealing a significant effect of emotion [$F(2, 37) = 11.265$, $p < 0.001$]. Post hoc analyses using Bonferroni-corrected multiple post hoc comparisons revealed differences between the neutral *vs*. negative ($p < 0.001$), and *vs*. positive ($p < 0.05$) pictures, but not between negative vs. positive pictures ($p > 0.05$).

Stimuli (see Fig. 1) consisted of two pictures, either one emotional and one neutral (10 negative/neutral and 10 positive/neutral) or two neutral pictures (10 neutral/neutral, included as fillers) on a black background and with a central fixation cross. Emotional and neutral pictures in each stimulus were normalized in terms of luminance level, root-mean-squared (RMS) contrast (Frazor & Geisler, 2006), and color saturation for the red, green and blue channels applying the histogram equalization method (Laughlin, 1981). Importantly, pictures were also matched in terms of the number of individuals displayed. In order to optimize foveal acuity, all pictures were reduced in size to 317 × 261 pixels, and had a visual angle of 13.3° by 10.9°. A central fixation point was located at 5.2° of visual angle from the inner edge of each picture (e.g., Calvo & Lang, 2004; Calvo *et al*., 2008). Two stimuli were created for each pair by inverting the side of the pictures (later referred to as laterality).

Procedure

Stimuli were displayed on a 17" monitor Dell computer with a 60-Hz refresh rate. Participants' eye movements were continuously sampled with the faceLAB Eye Tracker (Version 4.6, Seeing Machines). The Gaze Tracker Eye Analysis software (Version 8.0, Eye Response Technologies) controlled stimulus presentation and response collection.

The experimental task was to judge, following free exploration of the each stimulus, whether the two pictures depicted the same emotion or not, with no information about the type of emotion or pairing being presented. Participants were seated in a comfortable chair in a quiet room at a viewing distance of 60 cm from the screen. Prior to the experiment a nine-point calibration was conducted and three practice trials were performed. There were two experimental blocks. Each block included 10 positive, 10 negative and 10 neutral stimuli in a fully randomized order. Each display was presented in the two blocks, once with the emotional picture on the left side and once with the emotional picture on the right side. Each trial started with a central cross that they were asked to fixate for 1 second, followed by the stimulus presented for 3 seconds, and followed by the response screen "Same emotion? Yes or No". Participants responded using two colored keys of the keyboard (green for "Yes" and red for "No") with no time limit.

Data analyses

Eye movement behavior, averaged across the two eyes, was recorded at a rate of 60 points per second (60 Hz). Gazepoints time-series, comprising the position of gaze in screen coordinates with associated time since stimulus onset, were analysed using ad-hoc Matlab 7.6 scripts. A series of gazepoints constituted a fixation when the first derivative of their position did not exceed 10 pixels spatially (approximately 0.4° visual angle) for a minimum of 12 consecutive gazepoints (corresponding to 200 ms). Each stimulus was divided in three regions: left and right, comprising the pictures displayed plus 15% to take into account recording noise (regions of interest, ROIs), and outside of the ROIs.

Inclusion criteria were used to ensure that only trials with valid eye-tracking recordings were included in the analysis. The first gazepoint had to be within a 10 pixels circle around the fixation cross and recorded maximum 0.1 second after the onset of the stimulus to ensure that the first fixation after disengaging from the central cross was correctly recorded. Second, outliers were removed from the data analysis. Within subject variables were square-root transformed, and data points that were isolated in the highest or lowest decile distribution were eliminated iteratively (see method in Cousineau & Chartier, 2010). Trials that were excluded on the basis of one of the eye-tracking data were excluded from all eye-tracking analyses but not from behavior analyses. Participants with less than 50% of trials included were excluded from the analysis. In the final sample of included participants and trials, there were no significant group differences on the number of gaze points recorded (M = 169.16, SD = 16.05, p = 0.47) or total number of trials included for each participant (M = 33.23, SD = 5.07, p = 0.33).

Three variables extracted from eye-tracking time-series concerned the first fixation in ROIs: the nature of the first ROI fixated (variable *First picture fixated*, emotional or neutral), the *Latency before* (both variables assessing early automatic orientation of attention) and the *Duration of the first fixation* (or disengagement, in which both early and late processes can intervene). We also extracted the *Relative time spent on the emotional picture* (number of gaze points in emotional ROI divided number of gazepoints in both emotional and neutral ROIs) to assess more controlled exploration of the stimulus. Three-way mixed-design ANOVAs (with Statistica, Version 7, StatSoft Inc.) were performed on time variables (*Latency before first fixation*, *Duration of first fixation*, *Relative time spent on the emotional picture* minus chance level [0.5]) including Group (secure, preoccupied, fearful, dismissing) as between-subjects factor. Emotion (positive and negative stimuli) and First picture fixated (emotional, neutral) as within-subjects factor, and Subjects, Sessions, Trials and Laterality of the emotional picture (left, right), as random factors. For the two remaining variables (*Accuracy*, corresponding to the percentage of trials in which participants correctly identified that the emotions were different, and *First picture fixated* is the emotional picture), averages were calculated for each recording session and separately for emotional pictures presented on the right and on the left side of the stimulus. The difference between these values and chance level [0.5] were analysed with a two-way mixed-design ANOVAs including Group as between-subjects factor, Emotion as within-subjects factor, and Subjects, Sessions and Laterality of the emotional picture as random factors. For all these analyses, we only calculated the main effect of factors of interests and the full interaction between these factors (3-way for the time variables, 2-way for the behavioral variables). All p values reported below were adjusted with the Greenhouse-Geisser epsilon correction for non-sphericity. The uncorrected degrees of freedom and the probability scores after correction are reported. Effects sizes (η^2) are reported for the significant results. Fisher's least significant difference (LSD) tests were used for post hoc comparisons. Note that, due to the

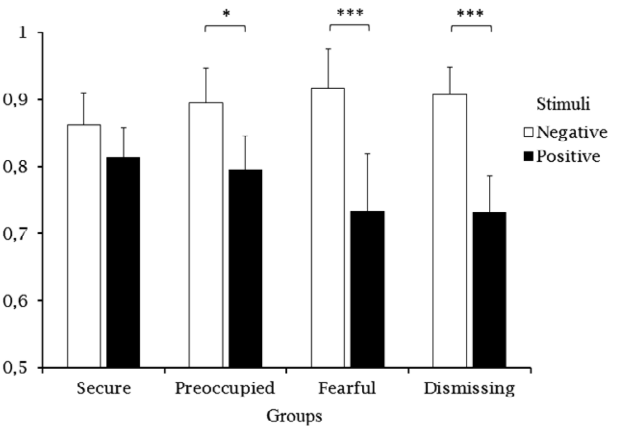

Fig. 2. Accuracy scores (ratio) on positive and negative stimuli for each group. Error bars are within-subject standard errors.

small sample size and the explorative nature of this study, no correction for multiple comparisons was applied.

RESULTS

Accuracy

Significance of the intercept [$F(1, 376) = 1227.86$, $p < 0.001$] demonstrated that accuracy was above chance. There was a main effect of Emotion [$F(1, 376) = 45.20$, $p < 0.001$, $\eta^2 = 0.10$], with negative stimuli ($M = 0.89$, $SD = 0.16$) being recognized more correctly than positive stimuli ($M = 0.77$, $SD = 0.19$, $p < 0.0001$). No main effect of group was found $F(3, 376) = 0.407$, $p = 0.75$]. The two-way interaction between Group and Emotion was also significant [$F(3, 376) = 3.17$, $p = 0.024$, $\eta^2 = 0.02$] (see Fig. 2). Results of post hoc analyses revealed that secure participants' recognition of emotions was independent of their emotional valence ($M_{\text{positive}} = 0.81$, $SD = 0.17$; $M_{\text{negative}} = 0.86$, $SD = 0.18$, $p = 0.14$). By contrast, for all the insecure groups, recognizing emotion was significantly less accurate for positive ($M_{\text{preoccupied}} = 0.80$, $SD = 0.16$; $M_{\text{fearful}} = 0.73$, $SD = 0.25$; $M_{\text{dismissing}} = 0.73$, $SD = 0.20$) than for negative ($M_{\text{preoccupied}} = 0.90$, $SD = 0.17$; $p = 0.010$; $M_{\text{fearful}} = 0.92$, $SD = 0.17$, $p < 0.001$; $M_{\text{dismissing}} = 0.91$, $SD = 0.14$, $p <0 .001$) stimuli. Between group comparisons showed that dismissing ($p < 0.017$) and fearful ($p = 0.038$) participants were significantly less accurate than secure ones when judging positive stimuli while the groups did not differ in their accuracy for negative stimuli (all ps > 0.15).

First picture fixated

The emotional picture was significantly fixated first [$F(1, 376) = 35.48$, $p < 0.001$]. Analyses showed a main effect of emotion [$F(1, 376) = 10.50$, $p = 0.001$, $\eta^2 = 0.03$], the emotional picture was fixated first for negative ($M = 0.63$, $SD = 0.27$) more often than for positive ($M = 0.54$, $SD = 0.30$) stimuli. Neither group [$F(3, 376) = 0.10$, $p = 0.96$] nor the interaction between group and emotion [$F(3, 376) = 0.82$, $p = 0.49$] reached significance. Further, the emotional preference was significantly above chance level for negative ($p < 0.001$), but not for positive ($p = 0.06$) pictures.

Latency before first fixation

Analyses showed a main effect of Group [$F(3, 1442) = 7.63$, $p < 0.001$, $\eta^2 = 0.01$]. Secure participants had the shortest latency before first fixation ($M = 0.56$ seconds, $SD = 0.21$), followed by the dismissing ($M = 0.57$ s, $SD = 0.20$), then preoccupied ($M = 0.60$ s, $SD = 0.19$), and the fearful had the longest latency ($M = 0.63$ s, $SD = 0.25$). Post hoc analyses indicated that differences between the secure and the fearful ($p < 0.001$) and preoccupied ($p = 0.004$) and the differences between the fearful and the secure (as above) and dismissing ($p < 0.001$) were significant, while other comparisons were not (ps > 0.05), more indicative of a continuous variation between groups than a clustering of groups together. A main effect of Emotion [$F(1, 1442) = 10.05$, $p = 0.002$, $\eta^2 = 0.006$] was also found significant, revealing that all participants had longer latency times before the first fixation for positive ($M = 0.60$ s, $SD = 0.22$) than negative stimuli ($M = 0.57$ s, $SD = 0.21$). The effect of the First picture fixated was not significant [$F(1, 1442) = 0.35$, $p = 0.54$]. Analyses also revealed a significant three-way interaction between Group, Emotion and First picture fixated, [$F(10, 1442) = 3.68$, $p < 0.001$, $\eta^2 = 0.02$] (see Fig. 3). Post hoc analysis of this interaction indicated that for negative stimuli, all groups had a comparable oculomotor response, with no significant difference in latency when the negative and the neutral pictures were fixated first (secure $p = 0.08$, preoccupied $p = 0.50$, fearful $p = 0.07$, dismissing $p = 0.37$). For positive stimuli in contrast, the fearful ($M_{\text{positive}} = 0.59$, $SD = 0.20$; $M_{\text{neutral}} = 0.71$, $SD = 0.28$, $p < 0.001$) and the preoccupied ($M_{\text{positive}} = 0.59$, $SD = 0.19$; $M_{\text{neutral}} = 0.68$, $SD = 0.22$, $p = 0.005$), but not the secure ($M_{\text{positive}} = 0.55$, $SD = 0.21$; $M_{\text{neutral}} = 0.56$, $SD = 0.21$, $p = 0.70$) and the dismissing ($M_{\text{positive}} = 0.58$, $SD = 0.19$; $M_{\text{neutral}} = 0.57$, $SD = 0.20$, $p = 0.78$), took longer when the first fixation was on the neutral than the emotional picture.

Duration of first fixation

Analyses showed a main effect of Group [$F(3, 1442) = 4.93$, $p = 0.002$, $\eta^2 = 0.01$], with the shorter time for the dismissing ($M = 0.39$ seconds, $SD = 0.18$) and the fearful ($M = 0.40$ s, $SD = 0.20$), compared to the secure ($M = 0.43$ s, $SD = 0.23$) and the preoccupied ($M = 0.44$ s, $SD = 0.24$) groups. The pattern was different than for the latency, identifying two groups with different disengagement strategies, with fearful and dismissing ($p = 0.59$) and secure and preoccupied ($p = 0.41$) rather similar, while other pairwise comparisons between groups reached significance level of $p < 0.05$ except fearful *vs*. secure, $p = 0.07$. First picture fixated was significant [$F(1, 1442) = 4.09$, $p = 0.043$, $\eta^2 = 0.002$], showing that the emotional picture ($M = 0.43$ s, $SD = 0.21$) was looked longer than the neutral one ($M = 0.40$ s, $SD = 0.22$). The Emotion effect was significant [$F(1, 1442) = 8.75$, $p = 0.003$, $\eta^2 = 0.01$], showing negative stimuli ($M = 0.44$ s, $SD = 0.23$) were fixated longer than positive stimuli ($M = 0.39$ s, $SD = 0.19$). The three-way interaction was also significant [$F(10, 1565) = 5.34$, $p < 0.001$, $\eta^2 = 0.03$] (see Fig. 3). For negative stimuli, all groups took significantly longer to disengage from the emotional ($M = 0.47$ s, $SD = 0.23$) than the neutral ($M = 0.38$ s, $SD = 0.22$) pictures (all ps ≤ 0.001),

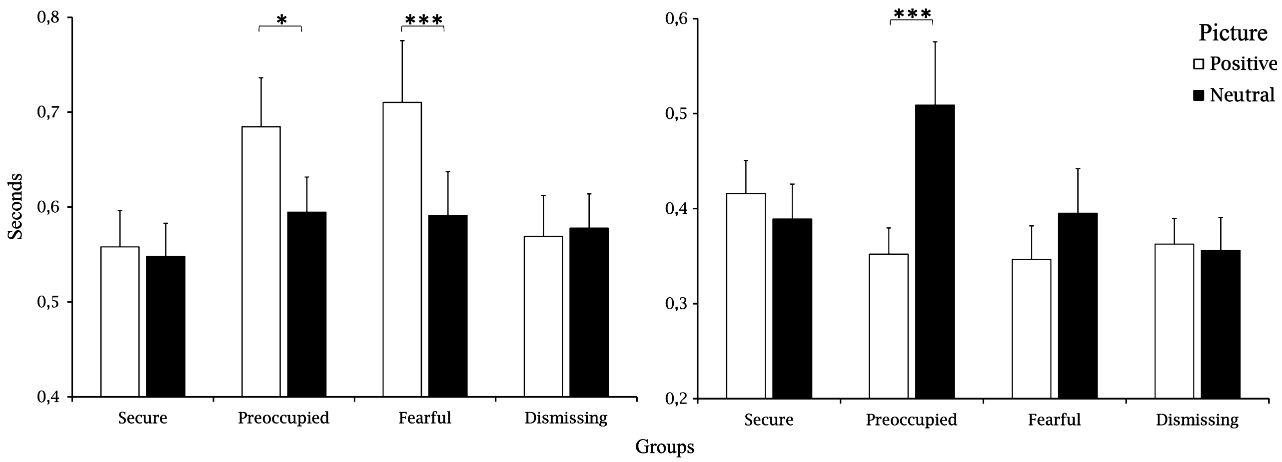

Fig. 3. Latency before (left) and duration of (right) first fixation (in seconds) on positive and neutral pictures for each group. Error bars are within-subject standard errors.

with no significant differences between groups for none of the two pictures (all *p*s ≥ 0.10). In contrast for positive stimuli, first fixation to the neutral picture by the preoccupied (M = 0.51 s, SD = 0.29) was significantly longer than to the emotional picture (M = 0.35 s, SD = 0.14, $p < 0.001$), while no such difference was visible in the other groups (Secure: M_{positive} = 0.42 s, SD = 0.21; M_{neutral} = 0.39 s, SD = 0.20; Fearful: M_{positive} = 0.35 s, SD = 0.16; M_{neutral} = 0.40 s, SD = 0.20; Dismissing: M_{positive} = 0.36 s, SD = 0.15; M_{neutral} = 0.36, SD = 0.16 s; all *p*s > 0.1). In agreement, this duration was significantly longer for the preoccupied than other groups for neutral (all *p*s < 0.001) pictures. Also noticeable, the secure group looked longer when fixating the positive picture first compared to all insecure groups (all *p*s < 0.05).

Relative time spent on the emotional picture

The significance of the intercept [$F(1, 1442) = 5.28$, $p = 0.023$] indicated that overall, participants spent more time on the emotional than on the neutral pictures, though the bias was small (M = 0.51, SD = 0.15). Analyses showed a main effect of Emotion [$F(1, 1442) = 13.31$, $p < 0.001$, $\eta^2 = 0.008$], with more time spent on emotional picture compared to chance for negative (M = 0.53, SD = 0.15, $p < 0.001$) but not for positive (M = 0.50, SD = 0.14, $p = 0.33$) stimuli. The main effect of the First picture fixated was also significant [$F(1, 1442) = 50.82$, $p < 0.001$, $\eta^2 = 0.03$]. The relative time spent on the emotional picture was higher than chance when the emotional picture was fixated first (M = 0.54, SD = 0.15, $p < 0.01$) and *vice-versa* when the neutral picture was fixated first (M = 0.48, SD = 0.13, $p = 0.002$), meaning that on average the picture fixated first was gazed longer than the other one. No other significant effect was found.

DISCUSSION

In this experiment we tested whether oculomotor behavior is influenced by attachment styles. Participants freely observed pairs of pictures depicting social interactions for 3 seconds and were asked to judge whether the pictures were emotionally similar or different. Present results showed different effects for positive and negative pictures, with attachment style influencing the behavior to positive pictures only, and mainly in the early exogenous processes. Irrespective of attachment style, the negative picture attracted the first fixation, the latency before first fixation was shorter for negative than for positive pictures, and disengagement from the negative picture took longer than from the neutral one. The significant increase of overall accuracy for negative stimuli, relative to positive ones, further suggested that the recognition of the emotion was easier for negative valence. This suggests a more automatic processing of negative compared to positive emotional content, therefore relying more on exogenous orientation of attention. Attentional biases to threatening stimuli have been associated to a facilitated attentional engagement towards, and a delay in the disengagement away from, threat (e.g., Koster, Crombez, Verschuere, Van Damme & Wiersema, 2006). Indeed, threat processing is subserved by dedicated brain areas and hard-wired circuits, in particular the evolutionary ancient amygdala (Sander, Grafman & Zalla, 2003), operating in an automatic fashion independent of higher cognitive processes (LeDoux, 1996, 2012; Öhman & Mineka, 2001). Efficiently detecting information about potential threats in order to rapidly adapt behavior is crucial for survival, thereby providing an evolutionary advantage (Esteves, Parra, Dimberg & Öhman, 1994; Öhman, 1993; Öhman, Lundqvist & Esteves, 2001). This has been demonstrated independently of the type of threat, whether evolutionary-relevant (e.g., snakes, spiders; Blanchette, 2006), modern (guns, syringes; Blanchette 2006) or social (e.g., real faces; Horstmann & Bauland, 2006) threats, like the stimuli used here (see example illustrated in Fig. 1). Altogether, our data suggests that when information pertained to negative social interactions, more recent threats in an evolutionary perspective, and not to fearful stimuli *sensu stricto*, the negative information processing was immune to attachment style. This finding did not fit theoretical predictions, nor previous studies reporting either attention orienting away (e.g., threatening attachment-related words, Dewitte *et al.*, 2007; angry faces, Dewitte & De Houwer, 2008) or towards negative cues (e.g., angry faces, Niedenthal *et al.*, 2002) as a function of attachment style. Within this sample of individuals we found instead a pattern of response in line with a more general evolutionary theoretical background, where detection of negative emotions operated at a very low perceptual level unconstrained from later emerging cognitive processes (LeDoux, 2012; 1996; Öhman and Mineka, 2001). In such a perspective, the attachment styles, thought to be refined by personal experience (e.g., Bowlby, 1973) would be more related to higher levels of social cognition, and therefore, would not interfere with these processes.

Results for positive emotions were radically different. First, the bias towards fixating the emotional picture first did not reach significance ($p = 0.06$) and the latency before first fixation was longer than for negative stimuli. The exogenous attraction of attention was reduced for positive compared to negative emotions. It is proposed that while threat detection is crucial for survival and has an old ontological history and dedicated circuitry, behaviors associated with positive affects should be considered as by-products of circuits involved in more complex behaviors such as nutrition, reproduction, and kinship (e.g., LeDoux, 2012). In mammals (see example of rats laughter in Panksepp & Burgdorf, 2003), and humans in particular, these systems would have been exapted to support social interactions and affiliative behaviors. Therefore, detecting emotionally positive information would not only be less urgent than negative valence information (e.g., Pratto & John, 1991), but also highly related to social interactions and involving evolutionary recent circuits and areas (compare brain response to scenic images eliciting positive vs. negative emotions in Figures 2 and 3, Radua, Sarró, Vigo *et al*., 2013).

In such a perspective, it is unsurprising that processing of positive information was permeable to attachment styles given that they reflect differences in how individuals apprehend social interactions. Already at the task level, all insecurely attached groups showed a reduced accuracy for positive stimuli, that could be explained either by an increased attribution of positive content in neutral pictures or decreased ability to recognize positive content in positive pictures. The absence of a group effect and the higher accuracy for negative emotions, in which neutral pictures were also used, supports the second proposal, namely, that insecure attachment style groups were less sensitive to the positive content of social scenes. Furthermore, dismissing and fearful were less accurate than the secure group, indicating that the avoidant styles were the least sensitive to positive emotions, probably motivated by their tendency to inhibit processing cues signaling interaction or attachment needs (Mikulincer & Shaver, 2003), while the preoccupied was not different from the secure group, possibly because of their hypervigilance to emotions (e.g., Silva *et al*., 2012). The positive picture was not explored longer than the neutral picture, supporting the idea that all participants equally explored the emotional and neutral pictures of the stimulus to accumulate information about the emotions displayed in each of them. Taken together, endogenous strategies to explore emotional content of positive valence did not appear to be influenced by attachment style, while the attribution of emotions, reflected in the accuracy, was.

Interestingly, attachment style influenced oculomotor behavior in the early processing stages of positive stimuli. The fearful and preoccupied groups took longer to perform their first fixation when it was on the neutral, but not the positive, picture, and the preoccupied fixated it longer than the positive picture or the other groups. A recent eye-tracking study investigating individuals suffering social anxiety (Chen, Clarke, MacLeod & Guastella, 2012) reported a fast disengagement from emotionally positive stimuli. This avoidance from positive emotions could explain the result of the two groups that had higher, but within the typical population range, anxiety scores on the Liebowitz Scale, the fearful and the preoccupied. These two attachment styles are known to have higher levels of anxiety when compared to the dismissing and secure (e.g., Bartholomew & Horowitz, 1991), even though anxious attachment involves a 'relation-specific anxiety' distinct from general forms of anxiety (Vrtička, Andersson, Grandjean, Sander & Vuilleumier, 2008). But such interpretation does not survive close scrutiny: we would expect to reproduce a reduction of the duration of the first fixation to the positive pictures in these groups, while what we observed was an increase of the duration of the first fixation to the neutral picture in the preoccupied group only.

We therefore propose an alternative interpretation that relies on how individuals with different attachment styles implicitly performed the task, which required recognizing the emotions depicted in two pictures. In contrast to negative pictures, for which exogenous attraction of attention facilitated the task (see previously), positive and neutral pictures were harder to disambiguate. The latency before the first fixation could reflect the need to gather sufficient information before making the first fixation. An increased latency for anxious groups, then, would be associated with an increase in the amount of information needed to reach the threshold, which is in line with their lack of self confidence and their fears concerning positive outcomes in social contexts (Bartholomew & Horowitz, 1991). In the same vein, the increased duration of this first fixation by preoccupied individuals only would signal that more information had to be gathered from the neutral picture to decide that it did not depict an emotion, in line with their uncertainties about the emotions of others (Bartholomew & Horowitz, 1991). Explaining why latency before the first fixation when it felt on the neutral, but not on the positive, pictures was increased in comparison to the secure and the dismissive groups is complex given that neither in their accuracy, nor in their first fixation, did any of the groups distinguish between these pictures efficiently. Altogether, it is interesting that the capture of attention by social stimuli with positive valence were abnormally processed in insecurely attached groups that are characterized by defective social functioning, supporting a specific role of positive emotions in social interactions; the finding that exogenous processes of attention orientation were affected is in agreement with the idea that attachment styles have strong biological underpinnings (Hari & Kujala, 2009).

CONCLUSION

To our knowledge this is the first eye-tracking study investigating oculomotor behavior in response to emotional pictures depicting social scenes of positive and negative valence in individuals as function of their attachment style. We report that the processing of positive, but not negative valence was affected by the attachment style. The current findings indicate that attachment groups with avoidant tendencies (dismissing and fearful) showed reduced accuracy involving a higher threshold for recognizing positive emotions compared to non avoidant groups. Conversely, the attachment groups with higher anxiety (preoccupied and fearful) showed differences in early markers of the visual exploration of the stimuli, and in particular, an increased delay preceding the first fixation to an emotional picture that may indicate reduced sensitivity to the implicit processing of positive emotions. While the results are promising, we acknowledge that the reduced sample size poses a challenge to the generalization of the present findings. Similarly, the experimental procedure must be refined to distinguish between alternative interpretations of the data.

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NOTES

[1] According to their IAPS numbers (Lang *et al*. 2001), the *neutral* pictures were: 2190 (Man), 2191 (Farmer), 2393 (Factoryworker), 2396 (Couple), 2570 (Man), and 2580 (Chess); the *positive* pictures were: 2154 (Family), 2299 (Family), 2341 (Children), 4599 (Romance), 4603 (Romance), and 8461 (HappyTeens); the *negative* pictures: 2800 (SadChild), 2811 (Gun), 3180 (BatteredFem), 3230 (DyingMan), 3301 (InjuredChild), 3530 (Attack), 3550 (Injury), 6313 (Attack), 9050 (PlaneCrash), and 9220 (Cemetery). Pictures used as *fillers* were: 2038 (NeuWoman), 2102 (NeuMan), 2214 (NeutMan), 2215 (NeutMan), 2235 (Butcher), 2305 (Woman), 2372 (Woman), 2381 (Girl), 2480 (ElderlyMan), 2485 (Man), 2487 (Musician), 2495 (Man), 2579 (Bakers), 2595 (Women), 2745.1 (Shopping), 2749 (Smoking), 2840 (Chess), 2870 (Teenager), 7493 (Man), and 8160 (RockClimber).

[2] A pilot study was conducted to assess the affective valence and arousal dimensions of the pictures drawn from commercially available sources. Forty-seven students (who did not engage in the actual experiment, $M_{\text{age}} = 19.8$, $SD = 7.3$) rated a total of 40 pictures for valence (from 1, *very pleasant*, to 9, *very unpleasant*), and arousal (from 1 *very stimulating*, to 9, very *unstimulating*) using the Self-Assessment Manikin (SAM; Bradley & Lang, 1994). Each image was presented in random order for 10 seconds, and participants were asked to make the valence and arousal ratings independently and to try to use the whole scale. According to the rating results, four emotionally positive ($M_{\text{valence}} = 7.00$, $SD = 0.32$; $M_{\text{arousal}} = 6.07$, $SD = 0.28$), and fourteen neutral pictures ($M_{\text{valence}} = 4.96$, $SD = 0.39$; $M_{\text{arousal}} = 4.63$, $SD = 0.83$) were selected.

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