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Investigation of attentional bias in anxiety through exposure to facial expressions: an eye-tracking study

Investigação do viés atencional na ansiedade por meio da exposição a expressões faciais: um estudo de rastreamento ocular

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Abstract

Objective
The present study investigated attentional biases in anxiety using facial expressions and eye-tracking measures.

Method
Seventy-six participants, between 18 and 36 years, took part in the study and were divided based on trait anxiety levels: Low, Moderate, and High. The stimuli were facial expressions, and the measures of interest were Probability of First Fixation and Proportion of Fixation Time.

Results
The results revealed vigilance biases towards expressions of disgust, regardless of anxiety level, and maintenance biases towards expressions of happiness, regardless of stimulus presentation time, in the Low Trait Anxiety group compared to the High Trait Anxiety group.

Conclusion
These findings raise questions related to the importance of using positive stimuli in anxiety treatment and the need to specify the types, levels, and characteristics of stimuli used in research.

Keywords: Anxiety; Attentional bias; Eye-tracking.

Resumo

Objetivo

O presente estudo investigou vieses atencionais na ansiedade utilizando expressões faciais e medidas de rastreamento ocular.

Método

Participaram 76 participantes, com idades entre 18 e 36 anos, divididos em função dos níveis de ansiedade traço: Baixa, Moderada e Alta. Os estímulos foram expressões faciais e as medidas de interesse foram a Probabilidade de Primeira Fixação e a Proporção do Tempo de Fixação.

Resultados

Os resultados evidenciaram vieses de vigilância para expressões de nojo, independentemente do nível de ansiedade, e vieses de manutenção para expressões de alegria, independentemente do tempo de apresentação dos estímulos, no grupo Baixa Ansiedade Traço, quando comparado com o grupo Alta Ansiedade Traço.

Conclusão

Tais resultados suscitam questões relacionadas à importância do uso de estímulos positivos no tratamento da ansiedade e à necessidade de especificar os tipos, níveis e características dos estímulos utilizados nas pesquisas.

Palavras-chave: *Ansiedade; Viés de atenção; Rastreamento ocular.*

Different neurocognitive models have been emphasizing the existence of biases in information processing in individuals with anxiety, highlighting their importance for the etiology and maintenance of this type of disorder (Fu & Pérez-Edgar, 2019; Mogg & Brendan, 2016). In the last decade, studies have investigated the interaction between anxiety symptomatology and biases in different cognitive functions involved in information processing, such as interpretation (Zhang et al., 2020) and memory (Lee & Fernandes, 2018), but primarily in selective attention (Gupta et al., 2019). In this regard, it is believed that the attentional system of individuals with high anxiety, especially those diagnosed with some type of anxiety disorder, is more sensitive to potentially threatening stimuli, thus exhibiting a bias to selectively attend to threat stimuli compared to positive or neutral stimuli (McNally, 2018).

The main explanatory models for the mechanisms responsible for this bias, known as Attentional Bias in Anxiety (ABA), are based on Posner's (2016) visuospatial attention component model. In this model, Posner (2016) proposes the existence of three distinct attentional systems: alerting, orienting, and executive attention. These systems are responsible for orienting attention to a region of the visual field, transferring it from a previously selected location to the relevant stimulus, performing or not performing eye movements that sustain a state of vigilance or alertness, and selecting the information necessary for performing voluntary, goal- or stimulus-driven cognitive processes (Posner, 2016).

Based on Posner's model, cognitive models that seek to explain ABA rely on the involvement of three specific attention-directing mechanisms: (a) vigilance toward the threatening stimulus; (b) maintenance or difficulty in disengaging attention from the threat; and (c) threat avoidance. While the first mechanism is related to sensory orientation and responds to involuntary events (stimulus-driven), allowing for its detection through automatic shifts in attention, the latter two mechanisms involve cognitive orientation and consist of voluntary attentional movements (goal-directed) toward the threatening stimulus while inhibiting involuntary distractor stimuli (Corbetta & Shulman, 2002).

The two most frequently investigated models in the literature that encompass these mechanisms are: the Vigilance-Avoidance Hypothesis (VAH) model and the Maintenance Hypothesis (MH) model. The VAH model is a complex model composed of both involuntary and voluntary mechanisms. It proposes that anxious individuals tend to more easily and frequently direct their attention to threat stimuli during the early stages of processing but tend to avoid the threatening stimulus at later stages of processing by reallocating their attention to another environmental cue (Armstrong & Olatunji, 2012). The MH model, on the other hand, is simpler and driven solely by inhibitory processes related to voluntary attentional control. It suggests that anxiety promotes excessive orientation toward the threatening stimulus and involuntary inhibition of distracting stimuli (Fu & Pérez-Edgar, 2019). Thus, although the MH model does not consider that there is a facilitated detection of threatening stimuli in anxious individuals, it postulates that when these individuals perceive a threatening stimulus, they remain attentive to it and have greater difficulty disengaging their attention from it (Armstrong & Olatunji, 2012).

Pertaining to how these models are investigated, initial studies that sought to examine ABA used Reaction Time (RT) measures, such as dot-probe tasks. Although these measures are still widely used in assessing vigilance and avoidance mechanisms in anxiety (e.g., Abend et al., 2018; Klein et al., 2018; Wei et al., 2020), they have been increasingly overshadowed by Eye-Tracking measures (ET) (e.g., Bardeen & Daniel, 2018; Fernandes et al., 2018; Lisk et al., 2020). This shift has been happening because RT measures have low temporal resolution, which makes it challenging to continuously measure attentional processing as they capture only the final stages of a sequence of multiple processes.

The ET measures allow for a continuous assessment of visual search through eye movements and, consequently, an assessment of attention (Armstrong & Olatunji, 2012). In this type of measurement, stimuli can also be presented over longer time intervals, which allows for its results to provide a dynamic registry of the functioning of the attentional system, assessing the course of attentional biases over time and at different stages of information processing (Dong et al., 2017). Furthermore, since tasks only require participants to make eye movements, issues related to the distal relationship between attentional processes and motor responses are also overcome (Armstrong & Olatunji, 2012).

Due to these characteristics, ET measures allow for a greater diversity of experimental paradigms in the study of ABA, especially regarding the assessment of gaze orientation over a continuum of time. This perspective has increasingly stimulated research development on the topic. Armstrong and Olatunji (2012) conducted a meta-analysis review of studies that employed ET measures in anxiety research. They assessed the experimental paradigms and ET measures used to study ABA. The authors identified 20 studies with experiments that employed free-viewing tasks, and five that used visual search tasks. The research results were favorable to a vigilance effect in anxious individuals for both types of tasks. Regarding maintenance, the results were inconsistent. This is because, although anxious individuals showed a marginal tendency to avoid looking at threat, specifically in experiments with visual search tasks, they exhibited a strong tendency to maintain gaze for a longer time toward the threat.

In these experimental paradigms, different classes of emotional stimuli have been used to investigate associations between ABA and anxiety (Armstrong & Olatunji, 2012). In particular, there has been growing interest in the use of socially relevant stimuli, such as facial expressions. Under typical conditions, effective identification of facial expressions is believed to be an essential skill that enables appropriate responses during interpersonal interactions and, therefore, functions as a central element of emotion perception and experience (Ekman, 1992). In this regard, it is possible to investigate whether anxious individuals have significant alterations in the processing of facial expressions due to ABA, which could underlie the etiology or maintenance of different types of anxiety disorders (Lazarov et al., 2016). It is important to note that emotions themselves vary in terms of parameters such as intensity, valence (i.e., positive or negative), and arousal. In general, researchers assume that such variation is also reflected in communication through facial expressions (Barrett et al., 2019), which justifies the importance of comparing the effects that can be elicited by exposure to different facial expressions.

To complement the data from Armstrong and Olatunji (2012), we performed a survey of studies on the use of ET measures in assessing ABA in the subsequent years. The objective was to provide a general overview of the research conducted in the years following the publication of Armstrong and Olatunji (2012) and gather evidence of the contribution of ET measures in investigating ABA. The search only considered experiments with free-viewing tasks, which totaled eight experiments. Among these, three supported the vigilance bias for threat stimuli in anxious individuals compared to non-anxious individuals, with only one of them showing vigilance-avoidance. Regarding maintenance, four out of the eight studies showed significant effects of this bias for threat stimuli in anxious individuals.

These results diverged from those found in the review and meta-analysis by Armstrong and Olatunji (2012). Thus, despite the indications in the literature that ABA may encompass the mechanisms involved in the VAH and MH models, it is still not clear whether all of them participate in the processing of this information, or even how this influence occurs. Investigating the reliability of these mechanisms is crucial for the development of intervention strategies that may become more accessible than traditional treatments, such as attention bias modification techniques (Chau et al., 2019; Jones & Sharpe, 2017).

The present study drew from the discussions raised about the experimental paradigms used in investigating ABA to develop a research protocol that could contribute to the assessment of ABA. Thus, the aim of this research was to investigate ABA through exposure to facial expressions using ET measures. As hypotheses, it is believed that: (hypothesis 1) regardless of the level of anxiety, individuals will show vigilance towards emotional faces compared to neutral faces; and (hypothesis 2) only individuals with higher levels of anxiety will show maintenance on threatening emotional faces.

Method

Participants

The research counted with a non-probabilistic convenience sample of 76 participants, mostly female (71.1%), with ages ranging from 18 to 36 years (*M* = 21.8; *SD* = 4.17). The inclusion criterion was being aged 18 and above. Exclusion criteria were: (i) participants with ocular diseases that could hinder their participation in the study; (ii) participants with some type of organic neuropsychiatric syndrome; (iii) participants with other neuropsychiatric disorders that did not qualify as an anxiety disorder; and (iv) participants with less than 80% of eye movements recorded. Five participants were excluded based on these criteria.

Instruments

Sociodemographic questionnaire – A form composed of specific questions for sample characterization (i.e., sex, age, and education) and specific clinical information for participant screening (i.e., presence of ocular diseases, diagnosis of organic syndromes, or other neuropsychiatric disorders).

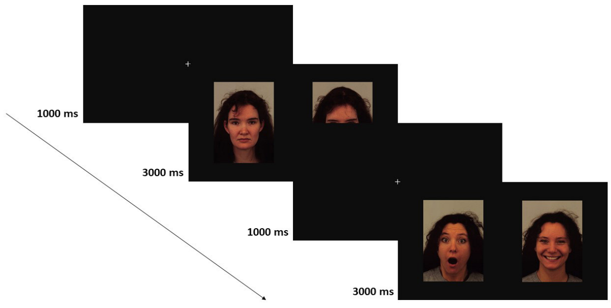
State-Trait Anxiety Inventory (STAI) – An instrument developed by Spielberger et al. (1970) and adapted for Brazil by Spielberger et al. (1979). It consists of two scales that assess anxiety as a trait (STAI-T) or as a state (STAI-S). In STAI-T, the participant must respond based on how they generally feel, using a 4-point Likert scale labeled as: 1 (Almost never), 2 (Sometimes), 3 (Often), and 4 (Almost always). In STAI-S, the participant must respond based on how they feel at the moment, using a 4-point Likert-type response scale labeled as: 1 (Not at All), 2 (Somewhat), 3 (Moderately So), and 4 (Very Much So).

Eye Tracker Tobii TX300 – Equipment based on infrared sensors, used to measure eye tracking (ET). The specified model is binocular and can be run at sampling rates of 60, 120, or 300 Hz. It was connected to a computer (Intel Core i7 processor) with a 23" widescreen monitor, which was used for stimulus presentation. Tobii Studio software version 3.4.0 was used for stimulus design and presentation, as well as for data output.

Stimuli

Sixty stimuli were used, each consisting of two competing facial expression images, one neutral face and the other showing anger, disgust, or happiness. Thus, each stimulus could have one of the six combinations of images: neutral-happy, happy-neutral, neutral-anger, anger-neutral, neutral-disgust, or disgust-neutral. The images were cropped to a size of 320 x 417 px and were positioned 275 px apart from the competing image. During presentation, each stimulus was displayed for 3000 ms, interspersed with a black background stimulus featuring a white cross in the center that lasted 1000 ms (Figure 1). The participant's task was to freely view the facial expressions and fixate their gaze on the white cross whenever it appeared.

Figure 1
Stimulus presentation scheme



The images were selected from the Karolinska Directed Emotional Faces (KDEF) (Lundqvist et al., 1998), and the choice of models and facial expressions to be used was based on the accuracy rates, intensity, and valence values provided in a complementary study conducted to support this research (Sales et al., 2020). Specifically, the five male and five female models with the highest accuracy rates in that study were selected. Only one of the male models had to be replaced because some of his images had significantly higher luminance than the others. Regarding the choice of facial expressions, faces of anger and disgust, which had higher average negative valence values, were used as negative stimuli, while faces of happiness, with higher average positive valence values, were used as positive stimuli. Neutral faces were used in contrast to all emotional faces. The 10 models selected from the KDEF were: AM08, AM10, AM14, AM17, AM31, AF09, AF13, AF14, AF16, and AF22. The database is freely available for research purposes at the following address: http://www.emotionlab.se/kdef/

Eye-tracking Measures

Eye-tracking measures were obtained from regions of interest that were drawn over the image pairs in each slide and on the entire image. Two measures were used: Probability of First Fixation (PFF) and Proportion of Fixation Time (PFT). The PFF was employed to assess the vigilance mechanism and represents the number of trials in which the participant's gaze was directed first to the target image, divided by the total number of trials. For PFF measures, fixations occurring within the first 100 ms were disregarded as an indicator of first fixation. Conversely, PFT was used to examine the maintenance and avoidance mechanisms and consisted of the total fixation time of the participant's gaze on the target image, divided by the sum of the total fixation time on both images. PFT measures were calculated by time segments. Thus, the PFTs for each type of facial expression were divided into six time segments of 500 ms each: T1 = 0-500 ms; T2 = 500-1000 ms; T3 = 1000-1500 ms; T4 = 1500-2000 ms; T5 = 2000-2500 ms; and T6 = 2500-3000 ms.

Procedures

The research was conducted in two stages. First, participants were contacted through social media (Facebook, Instagram, WhatsApp, etc.), email, and in-person invitations. Interested parties attended the data collection session at a scheduled time and date. After providing written consent through the Informed Consent Form (ICF), participants completed the sociodemographic and clinical questionnaire and the STAI-T. The second stage involved testing using the Eye Tracker. This stage lasted approximately 12 minutes and followed the following sequence of events: participants were directed to the eye-tracking equipment, where they positioned themselves, in a fixed position, at a distance of approximately 65 cm; calibration was then performed to synchronize the gaze point calculated by the Eye Tracker with the actual gaze position; then, the researcher provided the necessary instructions (e.g., try to remain as still as possible, avoid looking away from the screen, and try to minimize blinking); finally, when the participant had understood all the instructions, the presentation of stimuli began. Lastly, after the participant viewed all the displayed stimuli, they responded to the STAI-S and completed their participation in the research. The researchers involved were instructed to address any doubts about the research objectives after administering all tests, and to request that participants refrain from discussing this information with others.

Regarding ethical principles, this research obtained a favorable opinion from the Research Ethics Committee (CAAE: 95915518.0.0000.5188). We emphasize that the researchers involved adhered to all ethical principles outlined in Resolution 466/12 of the Brazilian National Health Council, which governs research norms involving human subjects.

Data Analysis

For data analysis, the IBM®SPSS® (version 25)software was used. Descriptive statistics (measures of central tendency and dispersion) were employed to characterize the sample, and

ANOVA with Bonferroni post-hoc tests were used to assess differences between groups/conditions. One-sample *t*-tests were used to compare the significant effects of the measures with chance (0.50). For one-way ANOVA, the Welch correction was applied when there was evidence of heterogeneity of variances (tested with Levene's test). For mixed-design ANOVA, if the assumption of sphericity was violated (tested with Mauchly's test), the Greenhouse-Geisser correction was used. A significance level of $p < 0.05$ was considered for accepting statistical significance. Only in the comparisons using one-sample *t*-tests that required Bonferroni corrections, more conservative values were considered (varying depending on the number of comparisons conducted).

Results

Aiming to test the suggested hypotheses, before conducting the analyses of eye-tracking measures, the sample was divided into three groups based on the tertiles of STAI-T scores. So, participants with scores equal to or below 42 formed the Low Trait Anxiety (LTA) group ($n = 26$; $M = 36.81$; $SD = 4.08$), participants with scores from 43 to 53 formed the Moderate Trait Anxiety (MTA) group ($n = 25$; $M = 48.12$; $SD = 2.60$), and participants with scores equal to or above 54 formed the High Trait Anxiety (HTA) group ($n = 25$; $M = 59.88$; $SD = 4.88$). The groups significantly differed in STAI-T scores, $F(2, 45) = 167.97$, $p = 0.000$, $\omega^2 = .92$, with post-hoc Bonferroni tests indicating significant differences between all groups (*p*-values < 0.001). Despite being low, the STAI-S scores also showed significant differences between the groups, $F(2, 73) = 11.47$, $p = 0.000$, $\omega^2 = 0.46$, with means of 33.85 ($SD = 6.06$) for the LTA group, 42.24 ($SD = 9.68$) for the MTA group, and 44.84 ($SD = 9.61$) for the HTA group. Post-hoc Bonferroni tests revealed significant differences between LTA and MTA ($p = 0.002$), between LTA and HTA ($p = 0.000$), but not between MTA and HTA ($p = 0.864$). After defining the groups, the analysis of eye-tracking measures was conducted.

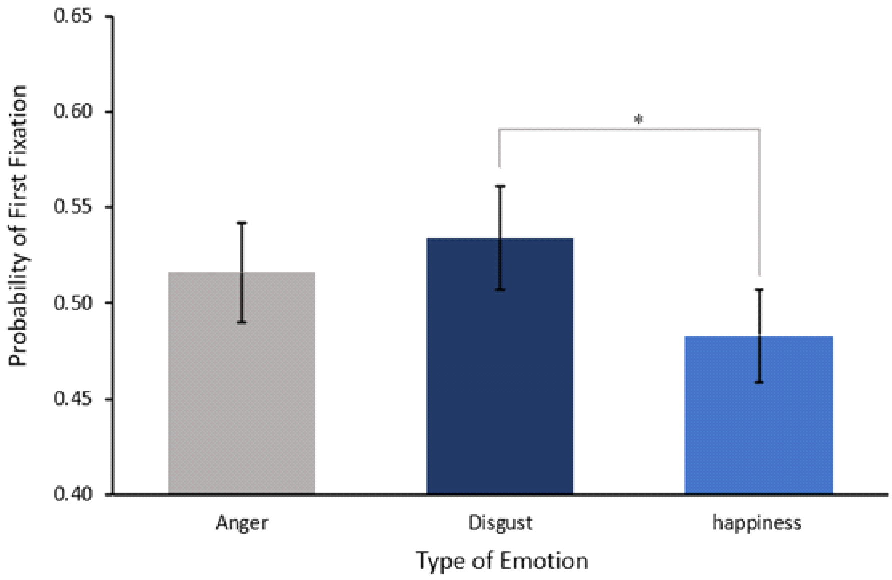
Vigilance

To investigate the vigilance mechanism, the PFFs for each type of facial expression (i.e., Happiness, Disgust, Anger, and neutral) were calculated. Initially, a mixed ANOVA with a 3 x 3 design was conducted, using the groups (LTA, MTA, and HTA) as the between-subjects variable and the type of facial expression (Happiness, Disgust, and Anger) as the within-subjects factor.

The results showed a significant main effect for the type of emotion, $F(1.7, 129) = 3.67$; $p = .033$; $\eta^2p = 0.05$. Post-hoc Bonferroni tests indicated that disgust facial expressions ($M = 0.53$; $SD = 0.11$) had significantly higher PFFs compared to happiness facial expressions ($M = 0.48$; $SD = 0.15$; $p = 0.043$). No significant main effect was found for anxiety level, and no interaction effect was found (*F* values < 0.75; $p > 0.547$; and $\eta^2p < 0.02$) (Figure 2).

Next, it was also tested whether the main effect of PFF found for the type of emotion was significantly higher than the value of 0.50. One-sample *t*-tests were conducted. For this analysis, a more conservative p-value ($p < 0.016$) was considered based on Bonferroni correction for multiple comparisons. The results showed that only for disgust facial expressions ($M = 0.53$; $SD = 0.11$), a significantly higher PFF than 50% was found, $t(75) = 2.79$; $p = 0.012$, indicating a bias toward disgust images, regardless of anxiety level.

Figure 2
Graphical display of Probability of First Fixation (PFF) for the overall sample for each emotion



Note: $^{*}p < 0.05$.

Maintenance and avoidance

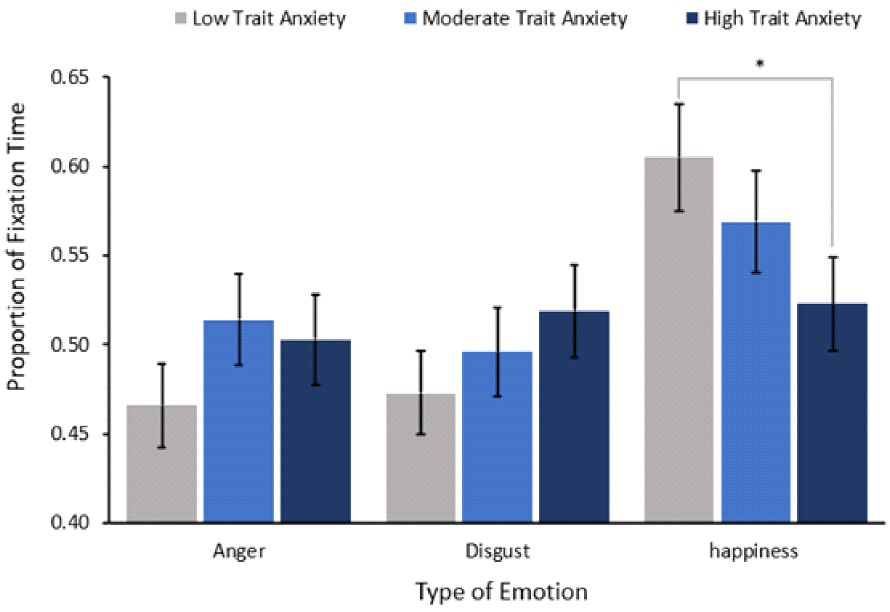
To investigate the mechanisms of maintenance and avoidance, the PFT measures were calculated by time segments. A mixed ANOVA with a 3 x 3 x 6 design was conducted, considering trait anxiety level (LTA, MTA, HTA) as the between-subject variable, and the type of facial expression (Happiness, Disgust, and Anger) and time segments (T1, T2, T3, T4, T5, and T6) as within-subject factors.

The results showed a significant main effect for the type of emotion, $F(1.4, 104) = 16.63$; $p = 0.000$; $\eta^2p = 0.19$. Post-hoc Bonferroni tests revealed significantly higher PFTs for happiness expressions ($M = 0.57$; $SD = 0.11$) compared to anger expressions ($M = 0.49$; $SD = 0.10$; $p = 0.000$) and disgust expressions ($M = 0.50$; $SD = 0.12$; $p = 0.000$). A significant interaction effect was found between the type of emotion and anxiety level, $F(2.8, 104) = 4.55$; $p = 0.006$; $\eta^2p = 0.11$. Post-hoc Bonferroni tests showed that the LTA group ($M = 0.60$; $SD = 0.13$) had significantly higher total PFTs compared to the HTA group ($M = 0.52$; $SD = 0.09$) for happiness images. For this interaction, one-sample *t*-tests, considering Bonferroni correction ($p < 0.008$), showed that total PFTs were significantly higher than 0.50 only for the LTA group, $t(25) = 4.13$; $p = 0.000$; and MTA group, $t(24) = 4.46$; $p = 0.000$; and only for happiness expressions. The differences in means between the groups can be observed in Figure 3.

A significant main effect for time was found, $F(2.8, 207) = 10.44$; $p = 0.000$; $\eta^2p = 0.12$. Post-hoc Bonferroni tests indicated that the PFTs of segments T2 ($M = 0.55$; $SD = 0.10$) and T3 ($M = 0.54$; $SD = 0.10$) were significantly higher than the PFTs of segments T4 ($M = 0.51$; $SD = 0.10$), T5 ($M = 0.50$; $SD = 0.11$), and T6 ($M = 0.49$; $SD = 0.11$; $p < 0.005$). A significant interaction effect was found between the type of emotion and time, $F(5.4, 398) = 3.59$; $p = 0.003$; $\eta^2p = 0.05$. Post-hoc Bonferroni tests showed that the PFTs for happiness, with means ranging from 0.56 ($SD = 0.16$; T6) to 0.59 ($SD = 0.15$; T3), were significantly higher than the PFTs for disgust in the T2, T3, T4, T5, and T6 time segments (*p*-values < 0.05), with means ranging from 0.46 ($SD = 0.16$; T5) to 0.53 ($SD = 0.13$;

Figure 3

Graphical display of Proportion of Fixation Time (PFT) for the groups for each emotion



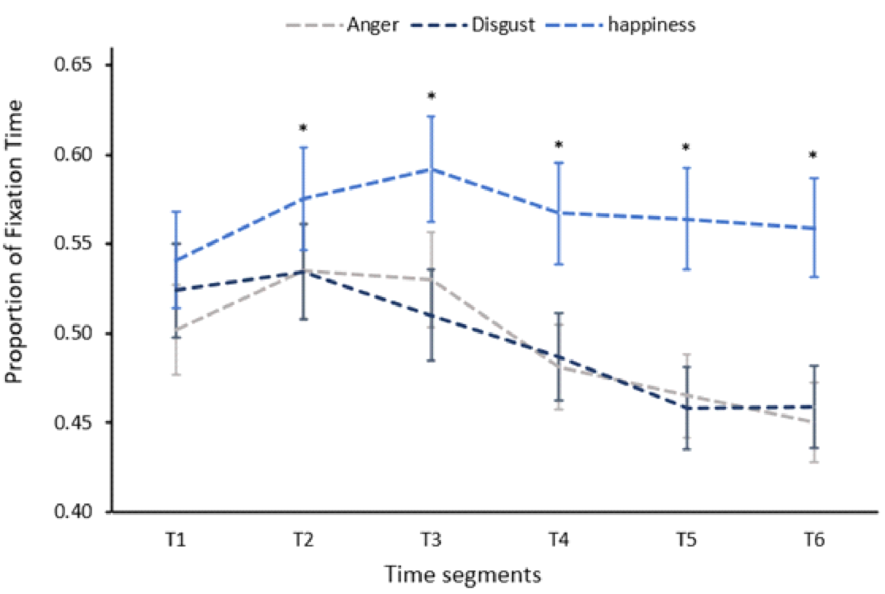
Note: *$p < 0.05$.

T2); and the PFTs for anger in the T3, T4, T5, and T6 time segments, with means ranging from 0.45 (*SD* = 0.16; T6) to 0.53 (*SD* = 0.13; T3). The differences in means between the time segments can be observed in Figure 4.

For this interaction, one-sample *t*-tests, considering Bonferroni correction ($p < 0.003$), showed that PFTs were significantly higher than 0.50 only for the emotion of happiness in the

Figure 4

Graphical display of Proportion of Fixation Time (PFT) for the overall sample for each emotion in time



Note: *$p < 0.05$.

T2, T3, T4, T5, and T6 segments (p-values < 0.002), and partially significant in the T1 segment ($p = 0.003$). Finally, there were no significant main effects for anxiety level, or interaction effects for time with anxiety level, or time with anxiety level and type of emotion (F values < 0.70; $p > 0.735$; and $\eta^2p < 0.02$).

Discussion

The aim of this research was to investigate ABA through exposure to facial expressions and the use of ET measures. To this end, we examined the potential presence of three mechanisms frequently reported in cognitive theories on the subject: vigilance, avoidance, and maintenance. This type of processing has been studied using a wide range of experimental paradigms, which have consistently yielded disagreements regarding the presence of these mechanisms. In this study, it was expected for the vigilance pattern to occur regardless of anxiety level (hypothesis 1) and for the data to support the MH (hypothesis 2). Neither hypothesis was supported. Furthermore, while partially agreeing with some of the cited studies, the results revealed a differential attentional processing and highlighted fundamental issues related to the importance of positive stimuli in anxiety and to the specific types, levels, and characteristics of the stimuli used in research.

Regarding the investigation of vigilance bias, hypothesis 1 suggested that most studies propose that anxious participants, compared to non-anxious participants, exhibit facilitated detection of threat-related images (e.g., Shechner et al., 2013) or emotional images in general (e.g., Calvo & Avero, 2005). The data from this study, assessed through PFF measures, did not find any differences based on anxiety level. Instead, all participants, regardless of anxiety level, showed higher PFFs for threat (i.e., emotional facial expressions contrasted with neutral facial expressions), specifically for expressions of disgust.

Despite the inconsistency of the data with the literature, the findings indicated a trend that has been observed in other studies that also did not find evidence of vigilance biases in anxiety (e.g., Fernandes et al., 2018; Nelson et al., 2015; Shechner et al., 2017). For instance, in a study by Nelson et al. (2015), vigilance in anxiety was investigated using an experimental paradigm that considered both trait and state anxiety. Regardless of trait or anxiety level, vigilance bias was observed for both threat images (i.e., images involving the potential harming of a person) and positive images. Based on this, the authors suggested that vigilance for emotional stimuli could be a normative characteristic and a likely result of individuals' adaptive defense system in general. Similar results have also been described in other research (e.g., Calvo & Avero, 2005; Quigley et al., 2012).

In this study, vigilance was not found for positive facial expressions, but only for threat facial expressions (i.e., Disgust and Anger). In particular, although the difference was not significant, disgust images showed higher mean PFFs than anger images. Because of this, Nelson et al.'s (2015) hypothesis about the normativity of vigilance would only explain why vigilance does not show differences for anxiety, but not why stimuli with positive emotions or different threats (e.g., anger) do not show the same bias. Thus, it is believed that this may have occurred due to some specific characteristic of facial expression stimuli - such as the fact that they are social stimuli, as only generic images were used as stimuli in other studies that found the same effect (e.g., Calvo & Avero, 2005; Nelson et al., 2015; Quigley et al., 2012).

Regarding the specificity of disgust expressions over anger facial expressions, it is possible to consider that the explanation may be related to the specific properties of emotions, such as intensity, valence, and mainly, arousal. This can be evidenced in the normative data of the face database used in this research (KDEF), which classified the disgust facial expressions as a threat option. In the study by Sales et al. (2020), for example, the results indicated that disgust expressions had more negative valence and higher levels of intensity than anger expressions. Furthermore, in the study that validated the KDEF itself, Goeleven et al. (2008) also provided data indicating greater intensity and arousal for disgust facial expressions compared to anger expressions. The measure of arousal is especially important in this case because it is related to the level of calmness or agitation that individuals may feel when viewing a face. Thus, higher values for this property suggest that faces may more easily elicit emotional states upon presentation. This may explain why participants in the HTA group had significantly higher scores on the STAI-S than the LTA group, despite generally low levels of state anxiety.

Unfortunately, it is difficult to ascertain the adequacy of this explanation since ET studies using disgust expressions are still scarce in the literature, which overwhelmingly favors the use of anger facial expressions as threatening stimulus. This may be an important gap as, despite the inconsistency of the results, the few studies found have shown that disgust expressions have significant effects on anxiety. In the studies by Holas et al. (2014) and Lazarov et al. (2016), the authors found vigilance and maintenance biases, respectively. The data from these studies, as well as normative data on facial expressions provided in validation studies (Goeleven et al., 2008; Sales et al., 2020), demonstrate that disgust facial expressions may play a more significant role than previously thought in the investigation of ABA and can be used as a threat option - which may even be more feasible than using anger expressions.

Regarding the PFT measures used to assess maintenance and avoidance biases, the results did not support hypothesis 2. The results showed that a main effect for time was found in the PFTs by time segment, characterized by PFTs close to 0.50 in the first 500 ms, followed by a higher PFT in emotional images in the time segments immediately after, with a subsequent decline. There was also an interaction effect with the type of emotion, such that happiness expressions, regardless of anxiety level, had higher PFTs than disgust and anger emotions - proportionally higher than 0.50 in all time segments after the first 1000 ms. It is believed that the lower PFT, as well as the absence of differences in PFT at the beginning of the presentation, is due to the participants' gaze location before the presentation of the face stimulus, where they are instructed to direct their gaze to a fixation cross, as described in the procedures. The viewing pattern in the sequence suggests that participants, when presented with stimuli displaying anger or disgust expressions, generally visit the facial expressions first and then visit the neutral expressions. These data, however, were not significantly different from 0.50 at either time point. Only in faces displaying happiness expressions do participants maintain a proportion of gaze on the facial expression until the end. There was no interaction between emotion, time, and anxiety level, so it is not possible to specify at which point in the stimuli presentation was there a greater influence of anxiety level.

Nevertheless, regardless of the time segment, a main effect for emotion and an interaction of facial expression with anxiety level were found. This interaction was the main result of this research. The data showed that during the 3000 ms of the presentation of each stimulus, individuals with low trait anxiety, compared to those with high trait anxiety, spent more time fixating on images of happiness compared to those of anger and disgust, with these values even exceeding the proportion of 0.50. These data suggest that the pattern of gaze maintenance on positive images is a natural attentional processing in individuals with low levels of anxiety but absent in individuals with higher levels of anxiety. Although this does not imply avoidance of positive images by individuals with high anxiety levels, it shows that this group engages in visual contact with positive stimuli much less than the low anxiety group. These results are consistent with some specific studies on social anxiety (e.g., Liang et al., 2017; Schofield et al., 2015).

In the study conducted by Liang et al. (2017), for example, the results also showed that non-anxious individuals directed more attention to happy faces than individuals with high anxiety, but only in the final stage of viewing, between 6 and 10 seconds after the start of each presentation. In the same research, it was also found that anxious individuals had difficulties disengaging from threatening facial expressions in the first 1000 ms of presentation. The explanation proposed by these researchers is that non-anxious individuals may have a greater capacity for emotional self-regulation, seeking to enhance the effect of positive feelings by intentionally focusing their attention on happy expressions during the final stage of presentation, while anxious individuals would have difficulties regulating their emotions. For this research, it is believed that the same may have occurred, despite the differences in time that can be explained by differences in the experimental paradigm used, being that Liang et al. (2017) used four images at a time, which caused the individual to spend more time scanning the stimulus until intentionally focusing on their preferred one.

The results obtained in this research provide relevant findings regarding the understanding of how attentional processing occurs in individuals with low and high levels of anxiety. Some findings are in line with research in the field, while others are not. Nevertheless, the conclusions drawn should be understood in light of some limitations. First, it should be noted that the sample was not diverse and was not balanced in terms of the variable sex. There was also no control for the type of anxiety, and the sample size may have limited the study's power. It is believed that with larger samples, interactions between time, anxiety level, and type of emotion would be found. Finally, it is a non-clinical sample, which makes it difficult to generalize the results to individuals with clinical diagnoses.

In relation to the experimental paradigm, only emotional facial images were used, so participants were only presented with two types of faces per stimulus, with one of them always being neutral. It would also be interesting to use generic images of situations and have a direct competition between positive and negative images and different types of threat. Another point to highlight is that despite not manipulating any anxiety-inducing stimuli, the data suggest that the images may have caused some level of arousal in the participants during the presentation, consequently providing some support for studies suggesting biases for state anxiety (Nelson et al., 2015; Quigley et al., 2012). As Nelson et al. (2015) suggested, it is possible that threat-related attentional biases are largely a state anxiety phenomenon, so the effects of trait anxiety found in previous studies would be because individuals with high trait anxiety would likely experience state anxiety more frequently and to a greater extent than individuals with low trait anxiety.

Final Considerations

Finally, it is reiterated that the data from this research, although not supporting the hypotheses raised, partially agree with previous studies on ABA, suggesting that the mechanisms involved may act in a more complex way than previously thought. The results showed not only a differentiated attentional processing of the mechanisms involved but also that they can be strongly influenced by variations in experimental paradigms. This fact highlights fundamental questions related to the specific types, levels, and characteristics of the stimuli used in research. More importantly, the results demonstrated that positive stimuli can play a fundamental role in attentional processing in anxiety. The results can be considered in future research investigating ABA, especially in clinical studies with intervention strategies based on attentional bias modification techniques, such as Attentional Bias Modification Training (ABMT), a fully computerized and operator-independent treatment approach that aims to intervene in the early stages of anxiety.

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