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RESEARCH ARTICLE

Analysis of attentional biases in anxiety using 24 facial priming sequences

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Abstract
The processing of emotional facial expressions helps people to adjust to the physical and social environment. Furthermore, mental disorders such as anxiety have been linked to attentional biases in the processing of this type of information. Nevertheless, there are still contradictory results that might be due to the methodology used and to individual differences in the manifestation of anxiety. Our research goal was to use 24 facial priming sequences to analyse attentional biases in the detection of facial expressions of fear, considering the levels and the ways in which individuals express anxiety. With higher levels of cognitive anxiety and general trait anxiety, those sequences that began in the upper half (vs. lower half) elicited a speedier response in the detection of fear. The results are discussed within the context of other techniques and disorders that prompt a deficit in the processing of facial information.

Keywords Detection · Emotion · Facial expression · Fear · Priming

Introduction

People have a specific ability to perceive faces that reflects the important role that face-transmitted information has in social interactions (Frith 2009), which becomes steadily more accurate from childhood (Herba and Phillips 2004; McClure 2000; Serrano et al. 1992) through to adolescence (Lawrence et al. 2015). Any alteration to these skills may give rise to inappropriate behaviours and misinterpretations of social situations (Kang et al. 2019), often being associated with mental health disorders (Demenescu et al. 2015). The bulk of the studies on anxiety disorders report that those individuals with a hight level record shorter response times (RTs) and greater precision in the detection of threatening facial expressions (fear and anger) (Claudino et al. 2019; Dyer et al. 2022; Leung et al. 2022; MacLeod and Rutherford 1992). Nevertheless, there also studies that do not find these results (Cooper et al. 2008; Philippot and Douilliez 2005), and there are even other studies that report the opposite (Jarros et al. 2012; Simcock et al. 2020). Such divergences can be explained by the different methods used for detecting emotional facial expressions (Attwood et al. 2017), as well as by the fact that most studies have analysed the differences between subjects that manifest high and low levels of cognitive anxiety, accepting the approach of cognitive models that suggest that anxiety is related to attentional biases during the initial processing stage (Dyer et al. 2022). However, scant attention has been paid to the differences between the levels of physiological response (physiological anxiety) and the motor one (motor anxiety) that might affect the sensitivity and speed of responses in behavioural tasks that measure attentional biases (Lang 1985; Lang et al. 1997).

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The processing of emotional facial expressions

Studies using the eye-tracking technique to analyse how we decode facial information have found that the triangle formed by the eyes and mouth is the main area of interest (Eisenbarth and Alpers 2011). Specifically, the eye area is the main focal point that automatically draws attention and generates a consistent neuronal response (Pesciarelli et al. 2016). This is due to the area's considerable ability to convey information, even on complex mental states (Lee and Anderson 2017). Nevertheless, the facial tracking strategies people use also depend on other factors, such as the context in which they take place (Wieser and Brosch 2012), personality (Ellingsen et al. 2019), culture (Haensel et al. 2020), or the type of emotion (Eisenbarth and Alpers 2011; Schurgin et al. 2014).

Considering both the type of emotion expressed and the first three eye fixations, more time is spent on the lower half of the face when expressions of happiness and disgust are identified, whereas more time is spent on the upper half when the expressions to be perceived are those of fear and sadness (Schurgin et al. 2014). Moreover, eye fixations on the face tend to be biased toward the left-hand side, from the viewer's perspective (LPB; Left Perceptual Bias, Gilbert and Bakan 1973; Proietti et al. 2015), with this tendency being found in both six-month-old babies and Rhesus monkeys (Guo et al. 2009). Although the use of eye-tracking techniques on a population without mental disorders has revealed characteristic patterns in facial perception processes (the focus of our attention and the time taken to determine a facial expression's emotional content), these are not upheld in the case of certain types of disorder, such as the Turner syndrome (Mazzola et al. 2006), epilepsy (Gómez-Ibáñez et al. 2014), autism spectrum disorders (Reisinger et al. 2020), behavioural disorders (Martin-Key et al. 2017), dementias (Hutchings et al. 2018); cranioencephalic traumas, schizophrenia (Mancuso et al. 2015), and affective disorders such as depression (Krause et al. 2021) and anxiety (Kang et al. 2019).

The processing of emotional facial expressions with high levels of anxiety

Different kinds of tasks have revealed a propensity to attend to, learn from, and use negative information to a greater extent than positive information (Vaish et al. 2008). This is readily apparent in anxiety disorders, in which priority is given to the processing of threatening information (NAB; Negative Attentional Bias, Browning et al. 2010). Anxiety is an emotional response that is triggered by the perception of danger. This is an adaptive response that improves personal performance, although it can become maladaptive when it is too intense and appears in situations in which there is a potentially threatening stimulus. Anxiety may be manifested through three different levels of response: cognitive (thoughts and feelings of concern), physiological (activation of the central and peripheral nervous system), and motor (e.g., motor agitation), which may be mutually modulated, and maintain a certain degree of independence (Lang 1968).

NAB has been found consistently in people with different anxiety disorders, using different experimental paradigms and conditions (Bar-Haim et al. 2007). It has also been associated with the anxiety trait in the population without mental disorders (e.g., Veerapa et al. 2020). Numerous studies have found that patients with high levels of anxiety (vs. control) are more sensitive to threatening facial expressions (Doty et al. 2013; Gutiérrez-García and Calvo 2017; Mogg et al. 2007; Yoon et al. 2014); they more often perceive neutral or ambiguous expressions as threatening (Bell et al. 2011; Heuer et al. 2010; Richards et al. 2002; Yoon et al. 2014); they record shorter reaction times in the recognition of threatening expressions compared to other kinds of facial expressions (Byrne and Eysenck 1995; Kang et al. 2019), and they have longer reaction times when disengaging their visual attention from threatening information (Fox et al. 2001). Nonetheless, although most studies report that anxiety has a facilitating effect in tasks involving the recognition and detection of threatening facial expressions (fear and anger), there are some scholars that do not find any effects, or even describe opposing ones (e.g., Cooper et al. 2008; Jarros et al. 2012; Suslow et al. 2019).

These contradictions may be due to the type of paradigm used, as well as to interpersonal variability in emotional response systems (cognitive, physiological, and motor). This variability in emotional response is precisely linked to interpersonal differences (Lang 1968), which is manifested through these three dimensions, and which determine the most suitable type of clinical treatment (Martínez-Monteagudo et al. 2012). For example, some people react more at a cognitive level than at a physiological or motor one, while others do so more physiologically, and not so much in cognitive terms.

Methods for analysing the processing of emotional facial expressions in anxiety

As regards the way in which NABs have been measured in anxiety, the Stroop test (Stroop 1935) was initially the one most widely used. It was subsequently challenged because the response latency forthcoming could involve other processes unrelated to attention. This was resolved by the appearance of another paradigm, *Dot probe* (MacLeod et al. 1986), based on the effect of priming. This type of task involves the simultaneous presentation of two stimuli with a different emotional valence. Once they disappear, the participants are required to detect as quickly as possible a point that appears in the same place occupied by one of the preceding stimuli. Although according to this paradigm anxious subjects manifest an attentional bias towards dangerous stimuli (they are quicker at detecting the point that appears in the position formerly occupied by a threatening stimulus, as opposed to another type of stimulus), this is not always the case for non-anxious ones (Bar-Haim et al. 2007). Nevertheless, studies conducted with an electroencephalogram (EEG) reveal that even non-anxious subjects pay more attention to stimuli that constitute a threat (Grimshaw et al. 2014; Holmes et al. 2009; Kappenman et al. 2014), although they do not remain fixated on them for as long as people suffering from anxiety (Kappenman et al. 2015). In other words, non-anxious people tend to focus more on threatening stimuli, but they can disengage themselves more quickly and effectively than their anxious counterparts. Studies using neuroimaging techniques therefore show that the differences between anxious and non-anxious individuals in the processing of threatening information is related to attentional disengagement in the later stages of information processing (Resh et al. 2019). Nevertheless, this preference for threatening information is not always observed in non-anxious individuals when they perform behavioural tasks such as *Dot Probe*.

These divergences between behavioural and neuronal measures might be due to the low internal reliability of behavioral tasks such as *Dot Probe* for detecting attentional biases because the time lapses commonly used between the onset of the stimuli with emotional valence and the appearance of the point that the individuals are required to detect (SOA; Stimulus Onset Asynchrony) are too long (500 ms), whereby their attention wanders before the point is displayed. When these times are shortened (100 ms), the task becomes more reliable (it detects the bias in non-anxious individuals). Nonetheless, although the reliability estimates are statistically more accurate with shorter SOA times, the figures are not high enough to justify the use of this test as a measure of the relationship between cognitive biases and other variables (Chapman et al. 2017).

Recent research has proposed a priming task in which the face is divided into four parts or segments, and it is presented consecutively as prime in all possible combinations (24 priming sequences). This approach "forces" the subject to process the face differently according to the priming sequence, thereby revealing which priming sequence is the most efficient in detecting the different emotional facial expressions. Regarding the expression of fear, the results of this research have revealed shorter RTs when the priming sequence begins in the upper part, continues downward to the right-hand side of the face, and then follows an anti-clockwise direction (Gordillo et al. 2020).

Nevertheless, this research did not compare the expression of fear to another type of expression with different facial tracking patterns. For example, this would be the case of an expression of disgust, where the viewer focuses longer on the mouth, compared to the expression of fear, where more time is spent on the eye area (Schurgin et al. 2014). The inclusion of the expressions of disgust together with fear in studies of this nature fulfil a dual purpose. On the one hand, it would enable us to verify the efficacy of the priming paradigm proposed by Gordillo et al. (2020) by presenting two facial expressions that differ in the segment that is of greatest relevance for the viewer, and which could modulate the RTs in a detection task. On the other hand, as they are both negative, this would control for the possible effect that emotional valence has on the results.

Individual differences in the manifestation of anxiety

Most of the tools used to measure anxiety have focused on the cognitive component (Muris 2005). Nevertheless, a task that involves pressing a key in the presence of a stimulus will also be influenced by levels of motor response, which might affect the processes of perception, selection, and action (Nieuwenhuys and Oudejans 2012). Furthermore, the levels of physiological response (arousal) might modulate modular attentional and memory processes when dealing with threatening stimuli or contexts (e.g., Brunyé and Mahoney 2019). It is therefore important to study the role played by cognitive, physiological, and motor activation in anxiety biases (Rozenman et al. 2017); above all because these response systems maintain a certain independence (Lang 1968), and might modulate the attentional bias in a different way.

Relevant information would therefore be lost if the anxiety trait were to be studied as a unique construct (Tobal and Cano-Vindel 1985) in a task containing cognitive components (which key to press and when), physiological ones (activation triggered by the threatening stimulus; facial expression of fear), and motor ones (pressing the appropriate key). These three components are interrelated, although they maintain a moderate correlation (Lang 1968), which implies a certain degree of fractioning and desynchrony that could prompt difference between individuals in detection tasks.

Some scholars, however, have created instruments that already take into account the triple system of emotional response, such as the Anxiety Situations and Responses Inventory—(ASRI; Miguel-Tobal & Cano-Vindel 2002), designed to measure anxiety within a clinical setting, and the School Anxiety Inventory (SAI; García-Fernández et al. 2011). The ASRI is the only one that evaluates the different kinds of response together with the situations generating them. This questionnaire caters for an accurate evaluation of cognitive responses and an initial approach to the appraisal of physiological and motor responses, as well as being a general measure of trait (general trait anxiety) (Fernández-Ballesteros 2004).

Objective and hypothesis

The objective here involves analysing whether the task of 24 facial priming sequences.is an appropriate way of analysing the attentional biases present in anxiety, considering the different response systems (cognitive, physiological, and motor), and general trait anxiety, which jointly evaluates the three response systems. We hypothesised that individuals with higher levels of cognitive anxiety response (centile > 50) are quicker at detecting the expression of fear when the priming sequences begin in the upper half of the face (vs. the lower part). (H_1). Higher levels of physiological anxiety response (centile > 50) are quicker at detecting the expression of fear when the priming sequences begin in the upper half of the face (vs. the lower part) (H_2); Higher levels of motor anxiety response (centile > 50) are quicker at detecting the expression of fear when the priming sequences begin in the upper half of the face (vs. the lower part) (H_3); Higher levels of general trait anxiety (centile > 50) are quicker at detecting the expression of fear when the priming sequences begin in the upper half of the face (vs. the lower part) (H_4). Differences are therefore expected between subjects with higher and lower levels of anxiety in all three response systems (cognitive, physiological, and motor), and in general trait anxiety. Furthermore, these differences are expected to follow the same sign, with faster responses when the priming sequences begin in the upper part of the face (vs. the lower one).

Sample

The sample consisted of 50 university students (Spain; 50% women; M ± SD age, 27.40 ± 7.17),who were rewarded with an increase of 0.50 points out of 10 in their marks in a subject. All the participants had normal or corrected eyesight and were right-handed. Before undertaking the task, each one of the participants signed their informed consent form.

Materials

The task was programmed using E-prime software. The 20 facial expressions of fear and neutral used (10 men and 10 women) were taken from the NimStim database (Tottenham et al. 2009). The facial expressions used in the test phase were provided by ten models with similar ages: five women (05F, 06F, 08F, 09F, 18F) and five men (21 M, 22 M, 28 M, 34 M, 36 M). In addition, use was made of the ISRA (Miguel Tobal and Cano Vindel 1986; Miguel Tobal and Cano-Vindel 2002), which is a self-report instrument in Situation-Response format that evaluates the manifestation rate of a series of responses: cognitive (thoughts and feelings of concern, fear, insecurity, etc.), physiological (sundry indices for the activation of sympathetic nervous activity and the sympathetic nervous system), and motor (several indices of motor agitation) involving anxiety in certain situations (e.g., *"When I think about all the things I have to do"*). Its original version has 528 items involving the combination of 24 responses grouped into three systems: cognitive (7), physiological (10), and motor (7), and 22 situations, grouped as follows: assessment (6), interpersonal (3), phobic (4), and day-to-day life (3). The authors subsequently drafted a reduced version of 224 items (Miguel Tobal and Cano Vindel 1986). The version applied in this study therefore contains 24 responses in anxiety, seven of a cognitive nature, ten of a physiological nature, and seven motor-type, along with the above 22 situations grouped into four kinds: assessment, interpersonal, phobic, and day-to-day life. The links between situations and responses provide a set of 224 items to be answered. The subjects are required to assess the rate at which responses are recorded at cognitive, physiological, and motor level with regard to each one of the 22 situations, considering a scale of 0 to 4 (0, almost never; 1, rarely; 2, sometimes; 3, often, and 4, almost always). The task lasts 40–60 min. The final score is the sum of the points given to each item in each one of the three levels (general trait anxiety). The test records excellent overall internal consistency (Cronbach's alpha) of 0.94, and good results for the response systems: Physiological (0.86), Cognitive (0.84), and Motor (0.70). In turn, good test–retest stability was recorded (0.78) and suitable external validity when correlating 0.87 with the original ISRA (Cano-Vindel et al. 2020).

Data availability

The datasets generated and analysed during the current study are available at this link: https://osf.io/nqwj3/?view_only=087d2846338e4aa99a52613ddd841f72

Procedure

The participants were placed in front of a 15″ screen with a resolution of 96 × 96 ppi at a distance of approximately 50 cm. They undertook the task on an individual basis, taking an average time of 20 min to do so. The computer screen displayed the task's instructions. Upon completion, they were thanked for taking part and then completed the ISRA questionnaire.

Task

The priming task (Gordillo et al. 2020) involved pressing the "B" key as quickly as possible when the screen displayed a facial expression of fear and not pressing it when the expression was neutral. Each one of the trials began with a priming sequence involving the four quarters of the face (each one measuring 4 cm wide and 5 cm high), which were displayed consecutively (50 ms each one) in all the possible sequences (24, as shown in Fig. 1). Finally, after the consecutive display of the four quadrants of the face (prime), the full facial expression was displayed (1.000 ms). The stimuli (8 cm wide and 10 cm high, full face) were displayed in the middle of a 15" screen, and approximately 50 cm away from the participants. The visual angle was 22.70º. In each trial, the prime and target sequences had the same model of face and the same emotional category. Overall, 480 trials were held (240 expressions of fear, 240 neutral expressions).

The statistical analyses involved grouping the priming sequences according to the following criteria: (1) Horizontal: variable that separates the sequences into two levels, those beginning on the left and those doing so on the right. (2) Vertical: variable that separates the sequences into two levels, those beginning below and those doing so above. (3) Angle: variable that separates the sequences into three levels depending on the angle formed by the first two quarters of the face in each sequence (0º, 45º, and 90º) (see Fig. 2).

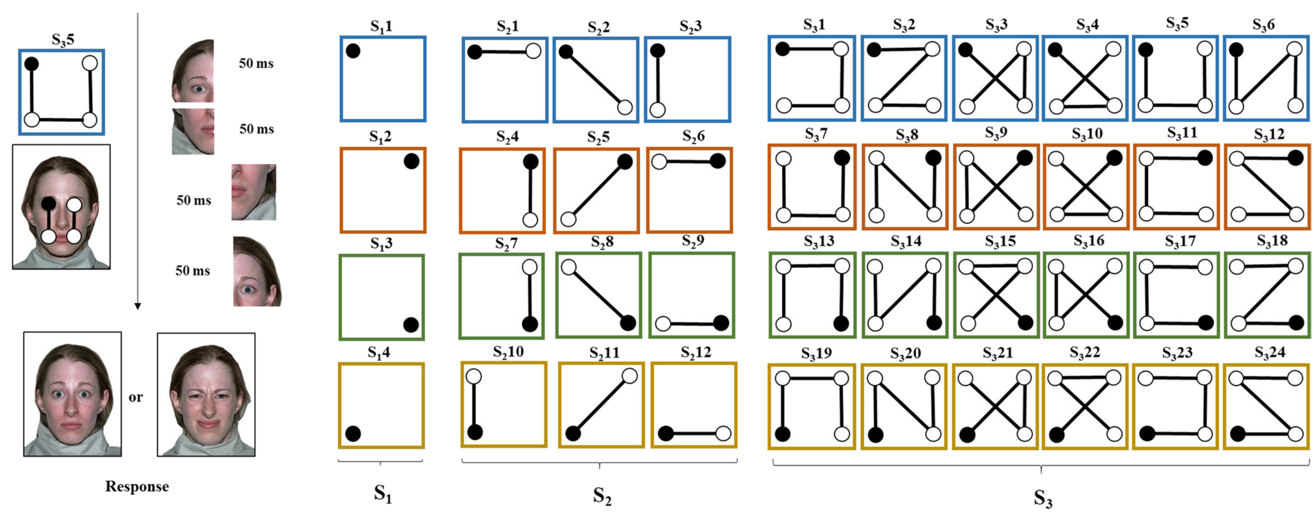

Fig. 1 Diagram of the procedure and of the 24 sequences (S3), as well as of the groupings in 12 sequences (S2), and in four sequences (S1). The black dot indicates

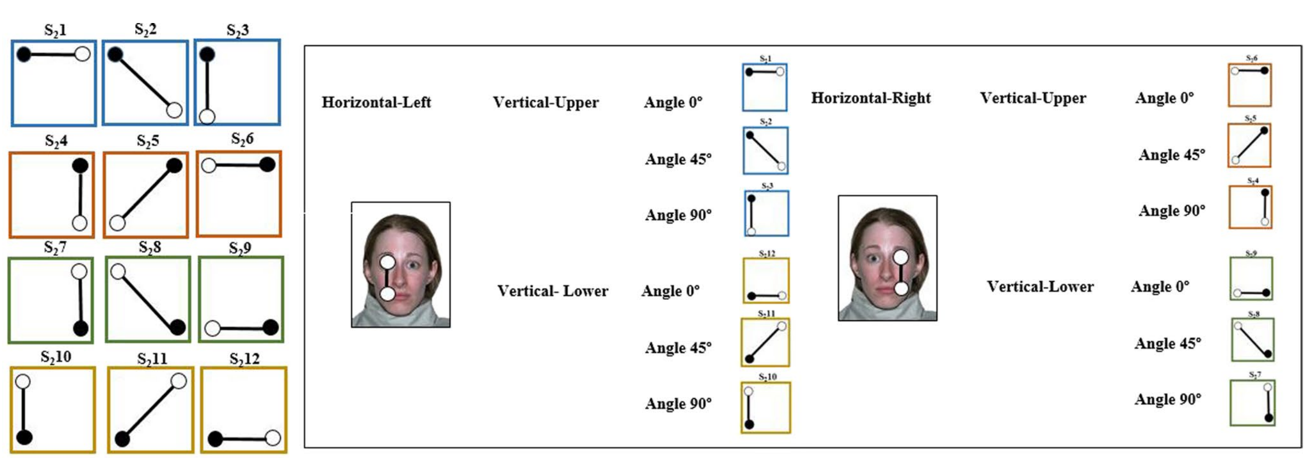

Fig. 2 Diagram of the priming sequences associated with the links between the levels of the variables Horizontal, Vertical, and Angle (2×2×3). The black dot

Statistical analyses

Normality tests were conducted to verify whether the data fulfilled a normal distribution involving each level of anxiety (cognitive, physiological, behavioural, and general trait anxiety) in relation to the comparison groups. Once it had been confirmed that they met criteria of normality, the decision was made to perform parametric analyses (Shapiro–Wilk, $p_s > 0.05$). In addition, an analysis was made of the differences in age and gender between the groups formed as of centile 50 in the different types of anxiety (Table 1). In view of the differences between some of the groups, the decision was made to include age as a covariable in the analyses. In turn, significant differences were found in the percentage of men and women, so a mixed ANOVA was conducted with Gender as between-subject variable, and Horizontal, Vertical, and Angle as within-subject variables. The results did not record any significant effects for Gender ($F_{(1, 48)} = 0.45$, $p = 0.506$, $\eta_p^2 = 0.01$), nor for the interaction between Gender and Horizontal ($F_{(1, 48)} = 0.18$, $p = 0.676$, $\eta_p^2 = 0.00$), Gender and Vertical ($F_{(1, 48)} = 0.67$, $p = 0.416$, $\eta_p^2 = 0.01$), or Gender and Angle ($F_{(1, 48)} = 0.25$, $p = 0.781$, $\eta_p^2 = 0.01$).

Considering the results recorded in the control analyses, the decision was made to conduct a mixed ANCOVA, 2 (Group: lower anxiety, higher anxiety) × 2 (Horizontal: left, right) × 2 (Vertical: lower, upper) × 3 (Angle: 0°, 45°, 90°), with the between-subjects variable, Group, consisting of those subjects scoring above and below centile 50 in cognitive, physiological, and motor anxiety, including age as covariable; and the within-subject variables, Horizontal, with two levels depending on whether the priming sequences began on the face's left- or right-hand side; Vertical, with two levels depending on whether the priming sequences began on the face's upper or lower half, and Angle, with three levels, depending on whether the first two facial quadrants in the priming sequence formed an angle of 0°, 45°, or 90°. RT was used as the measure of the dependent variable. The measure for RT involved recording the time (ms) taken to detect the emotional expression from its appearance on the screen until the subject presses the letter "B" on the keyboard. In addition, an ANCOVA was also conducted with the dependent variable being the overall scores in the three types of anxiety response (general trait anxiety).

Results

Cognitive anxiety response

The results did not reveal any significant effects of the variable Group, although there was a tendency toward significance ($p = 0.063$), with slower RTs in the group with higher levels of cognitive anxiety ($M = 594.60$, $SD = 18.23$), compared to the group with lower levels ($M = 549.84$, $SD = 22.38$). No significant effects were found in the variables Horizontal and Angle, although they were for Vertical ($M_{Lower} = 526.36$, $SD = 14.10$; $M_{Upper} = 518.09$, $SD = 14.77$) (Table 2).

Furthermore, significant effects were found for the interaction between Group and Horizontal (Table 2). The simple effects analysis recorded differences between subjects with

Table 2 Principal effects on cognitive anxiety response of the variables Group, Horizontal, Vertical, and Angle

	F	p	η_p^2	P
Group	3.63	.063	.07	.46
Horizontal	1.04	.314	.02	.17
Vertical	5.75	.021	.11	.65
Angle	.317	.729	.01	.10
Group*Horizontal	5.32	.026	.10	.62
Group*Vertical	11.65	.001	.20	.92
Group*Angle	.01	.994	.00	.05
Horizontal*Vertical	.12	.730	.00	.06
Horizontal*Angle	.64	.530	.01	.15
Vertical*Angle	1.04	.358	.02	.23
Group*Horizontal*Vertical	5.29	.026	.10	.62
Group*Horizontal*Angle	.28	.759	.01	.09
Group*Vertical*Angle	.67	.512	.01	.16
Horizontal*Vertical*Angle	.76	.,470	.02	.18
Group*Horizontal*Vertical*Angle	.04	.965	.00	.06

Table 1 Analysis of gender and age differences between the groups formed as of percentile 50

Anxiety	Centile 50		Centile < 50 (Lower)			Centile > 50 (Higher)			
	[Min–Max]	n	Age M (SD)	Gender Ratio F:H	n	Age M (SD)	Gender Ratio F:H	t Student (age)	Chi-square (gender)
Cognitive	62 [5–90]	20	26.15 (5.56)	7:13	30	28.23 (8.06)	18:12	.319	.083
Physiological	75 [5–99]	10	23.70 (4.79)	1:9	40	28.33 (7.42)	24:16	.068	.005
Motor	40 [5–80]	38	27.16 (7.24)	18:20	12	28.17 (7.22)	7:5	.676	.508
Trait anxiety	60 [10–95]	17	23.82 (4.05)	2:15	33	29.24 (7.77)	23:10	.010	< . 001

lower anxiety (M_i = 554.33, SE = 2.45) and higher anxiety (M_j = 492.36, SE = 28.30) in the sequences that began on the right-hand side ($M_{(i-j)}$ = 61.97, SE = 29.11, p = 0.039, 95% CI [3.41, 120.53]). Another significant effect was found in the interaction between Group and Vertical (Table 4), recording differences between the sequences beginning in the lower half (M_i = 504, SE = 17.90) and upper half (M_j = 485.20, SE = 18.76) in the higher anxiety group ($M_{(i-j)}$ = 18.81, SE = 3.88, $p < 0.0001$, 95% CI [11.00, 26.62]). There were also differences between subjects with lower anxiety (M_i = 550.98, SE = 23.02) and higher anxiety (M_j = 485.20, SE = 18.76) in the sequences that began in the upper half ($M_{(i-j)}$ = 65.78, SE = 29.84, p = 0.032, 95% CI [5.75, 125.81]).

The third-order interaction between the variables Horizontal, Vertical, and Group proved to be significant (Table 2). The simple effects analysis recorded differences between the left-hand side (M_i = 538.65, SE = 22.04) and the right-hand side (M_j = 558.76, SE = 22.25) ($M_{(i-j)}$ = − 20.11, SE = 5.54, p = 0.001, 95% CI [− 31.25, − 8.96]) in the sequences beginning in the lower half of the face within the lower anxiety group. By contrast, there were differences between the lower half (M_i = 507.11, SE = 19.14) and the upper half (M_j = 486.57, SE = 19.14) within the high-anxiety group in the sequences beginning on the left-hand side ($M_{(i-j)}$ = 20.54, SE = 5.51, p = 0.001, 95% CI [9.45, 31.63]), and between the lower half (M_i = 500.90, SE = 18.13) and the upper half (M_j = 483.82, SE = 18.79) within the high-anxiety group in the sequences beginning on the right-hand side ($M_{(i-j)}$ = 17.08, SE = 4.95, p = 0.001, 95% CI [7.13, 27.03]). There were also differences between the groups with lower anxiety (M_i = 552.06, SE = 23.49) and higher anxiety (M_j = 486.57, SE = 19.14) in the sequences beginning on the upper left-hand side ($M_{(i-j)}$ = 65.49, SE = 30.45, p = 0.037, 95% CI [4.24, 126.74]), and between the groups with lower anxiety (M_i = 549.90, SE = 23.06) and higher anxiety (M_j = 483.82, SE = 18.79) in the sequences beginning on the upper right-hand side ($M_{(i-j)}$ = 66.08, SE = 29.89, p = 0.032, 95% CI [5.95, 126.21]) (Fig. 3). Finally, no significant effects were found for any of the other interactions ($Fs < 1.20$, $p > 0.350$, $\eta_p^2 < 0.03$, $P < 0.23$) (Fig. 3).

Physiological anxiety response

The analyses did not find any significant effects for the variables Group, Horizontal, and Angle, but they did for the variable Vertical (M_{Lower} = 517.95, SD = 17.92, M_{Upper} = 512.32, SD = 19.24). No significant effects were found either for the interaction of the variables, but they were for the tendency toward the significance of the interaction between the variables Group and Vertical (p = 0.064) (Table 3), where the group with higher levels of physiological anxiety responded more quickly to the sequences beginning in the upper part of the face compared to those doing so in the lower part (M(i-j) = − 13.54, SE = 3.63, p = 0.001, 95% CI [− 20.85, − 6.24]).

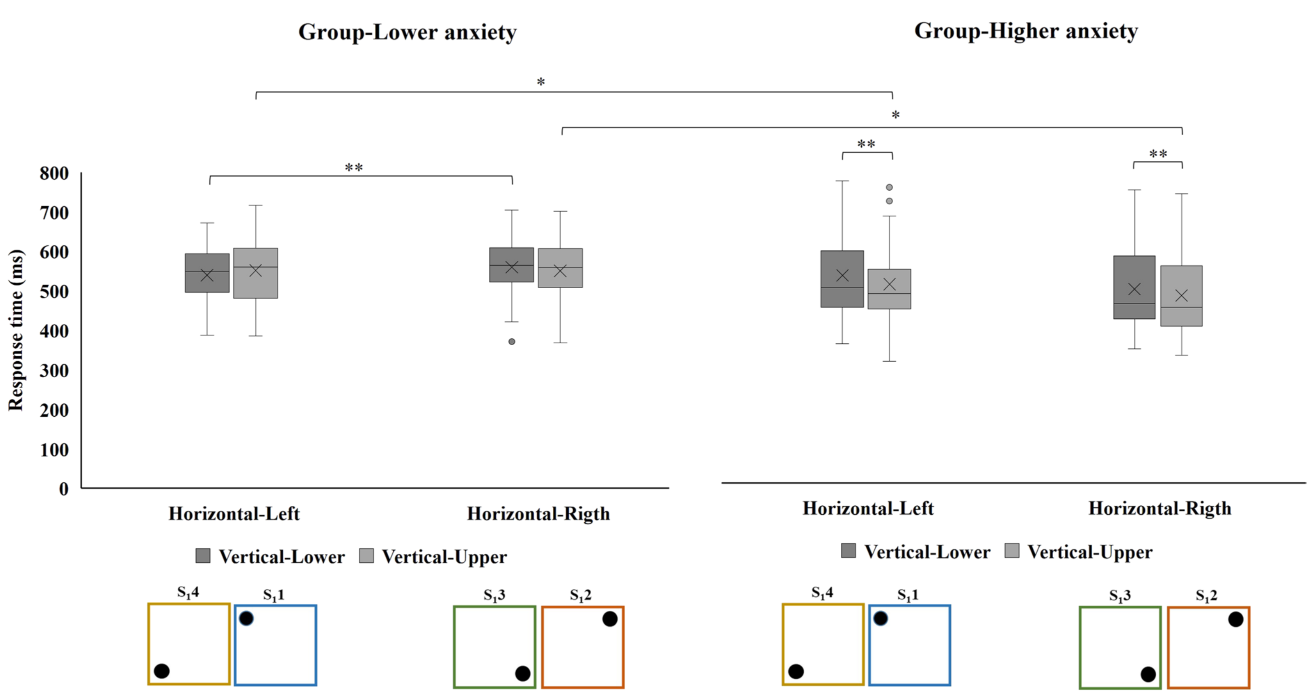

Fig. 3 Differences in RTs in the interaction of the variables Horizontal (left- and right-hand side), Vertical (lower and upper half) and Group (lower anxiety, higher

Table 3 Principal effects on the physiological anxiety response of the variables Group, Horizontal, Vertical, and Angle

	F	p	η_p^2	P
Group	.02	.891	.00	.05
Horizontal	1.47	.232	.03	.22
Vertical	4.31	.043	.08	.53
Angle	.26	.775	.01	.09
Group*Horizontal	.46	.500	.01	.10
Group*Vertical	3.60	.064	.07	.46
Group*Angle	1.10	3.38	.02	.24
Horizontal*Vertical	.03	.865	.00	.05
Horizontal*Angle	.57	.567	.01	.14
Vertical*Angle	1.12	.331	.02	.24
Group*Horizontal*Vertical	.26	.611	.01	.08
Group*Horizontal*Angle	.51	.601	.01	.13
Group*Vertical*Angle	.09	.916	.00	.06
Horizontal*Vertical*Angle	.83	.441	.02	.19
Group*Horizontal*Vertical*Angle	.26	.770	.01	.09

Table 4 Principal effects on the motor anxiety response of the variables Group, Horizontal, Vertical, and Angle

	F	p	η_p^2	P
Group	.01	.906	.00	.05
Horizontal	1.26	.268	.03	.20
Vertical	4.04	.050	.08	.50
Angle	.26	.770	.01	.09
Group*Horizontal	.01	.933	.00	.05
Group*Vertical	.56	.458	.01	.11
Group*Angle	.05	.955	.00	.06
Horizontal*Vertical	.00	.954	.00	.05
Horizontal*Angle	.51	.604	.01	.13
Vertical*Angle	1.07	.349	.02	.23
Group*Horizontal*Vertical	.14	.713	.00	.07
Group*Horizontal*Angle	.47	.625	.01	.13
Group*Vertical*Angle	.90	.411	.02	.20
Horizontal*Vertical*Angle	.93	.397	.02	.21
Group*Horizontal*Vertical*Angle	3.38	.038	.07	.62

Motor anxiety response

The analyses did not find any significant effects for the variables Group, Horizontal, and Angle, but they did for the variable Vertical ($M_{Lower}=523.71$, $SD=16.59$, $M_{Upper}=511.81$, $SD=17.80$). By contrast, significant effects were indeed found for the interaction between the variables Horizontal, Vertical, Angle, and Group. None of the other interactions recorded significant effects (Table 4).

The simple effects analysis recorded differences between the left-hand side ($M_i=522.76$, $SE=16.70$) and the right-hand side ($M_j=537.59$, $SE=17.39$), with lower anxiety in the sequences that began in the lower half with an angle of 0º ($M_{(i-j)}=-14.83$, $SE=5.56$, $p=0.010$, 95% CI [-26.02, -3.65]). There were likewise differences between the left-hand side ($M_i=521.54$, $SE=16.22$) and the right-hand side ($M_j=507.53$, $SE=17.09$), with lower anxiety in the sequences that began in the lower-half with an angle of 90º ($M_{(i-j)}=14.01$, $SE=6.45$, $p=0.035$, 95% CI [1.03, 26.98]). In turn, there were differences between the lower half ($M_i=537.59$, $SE=17.39$) and the upper half ($M_j=512.92$, $SE=17.52$), with lower anxiety in the sequences that began on the right-hand side with an angle of 0º ($M_{(i-j)}=24.67$, $SE=6.49$, $p<0.0001$, 95% CI [11.62, 37.73]). There were differences between the lower half ($M_i=534.20$, $SE=29.80$) and the upper half ($M_j=507.58$, $SE=31.53$), with higher anxiety in the sequences that began on the right-hand side with an angle of 45º ($M_{(i-j)}=26.62$, $SE=12.24$, $p=0.035$, 95% CI [1.99, 51.24]). There were also differences between the lower half ($M_i=529.42$, $SE=30.44$) and the upper half ($M_j=499.30$, $SE=33.06$), with higher anxiety in the sequences that began on the right-hand side with an angle of 90º ($M_{(i-j)}=30.12$, $SE=10.54$, $p=0.006$, 95% CI [8.93, 51.32]). Finally, differences were found between the angle of 0º ($M_i=537.59$, $SE=17.39$) and the angles of 45º ($M_j=521.29$, $SE=16.73$) ($M_{(i-j)}=16.30$, $SE=6.14$, $p=0.011$, 95% CI [3.95, 28.66]) and 90º ($M_j=507.53$, $SE=17.09$) ($M_{(i-j)}=30.06$, $SE=5.64$, $p<0.0001$, 95% CI [18.73, 41.30]), as well as between the angles of 45º ($M_i=521.29$, $SE=16.73$) and 90º ($M_j=507.53$, $SE=17.09$) ($M_{(i-j)}=13.76$, $SE=6.31$, $p=0.034$, 95% CI [1.06, 26.46]), within the low-anxiety group in the sequences beginning on the lower right-hand side (Fig. 4).

General trait anxiety

No significant effects were found for the variables Group, Horizontal, and Angle, but they were found for the variable Vertical ($M_{Lower}=520.44$, $SD=15.06$; $M_{Upper}=513.66$, $SD=16.14$). In turn, significant effects were found for the interaction between Vertical and Group. None of the other interactions recorded significant effects (Table 5).

The simple effects analysis revealed differences between the sequences that began in the lower half ($M_i=524.96$, $SE=17.86$) and the upper half ($M_j=506.94$, $SE=19.15$) in the high-anxiety group ($M_{(i-j)}=18.02$, $SE=3.81$, $p<0.0001$, 95% CI [10.35, 25.67]).

Discussion and conclusions

The objective here involves analysing whether the task of 24 facial priming sequences.is an appropriate way of analysing the attentional biases present in anxiety, considering

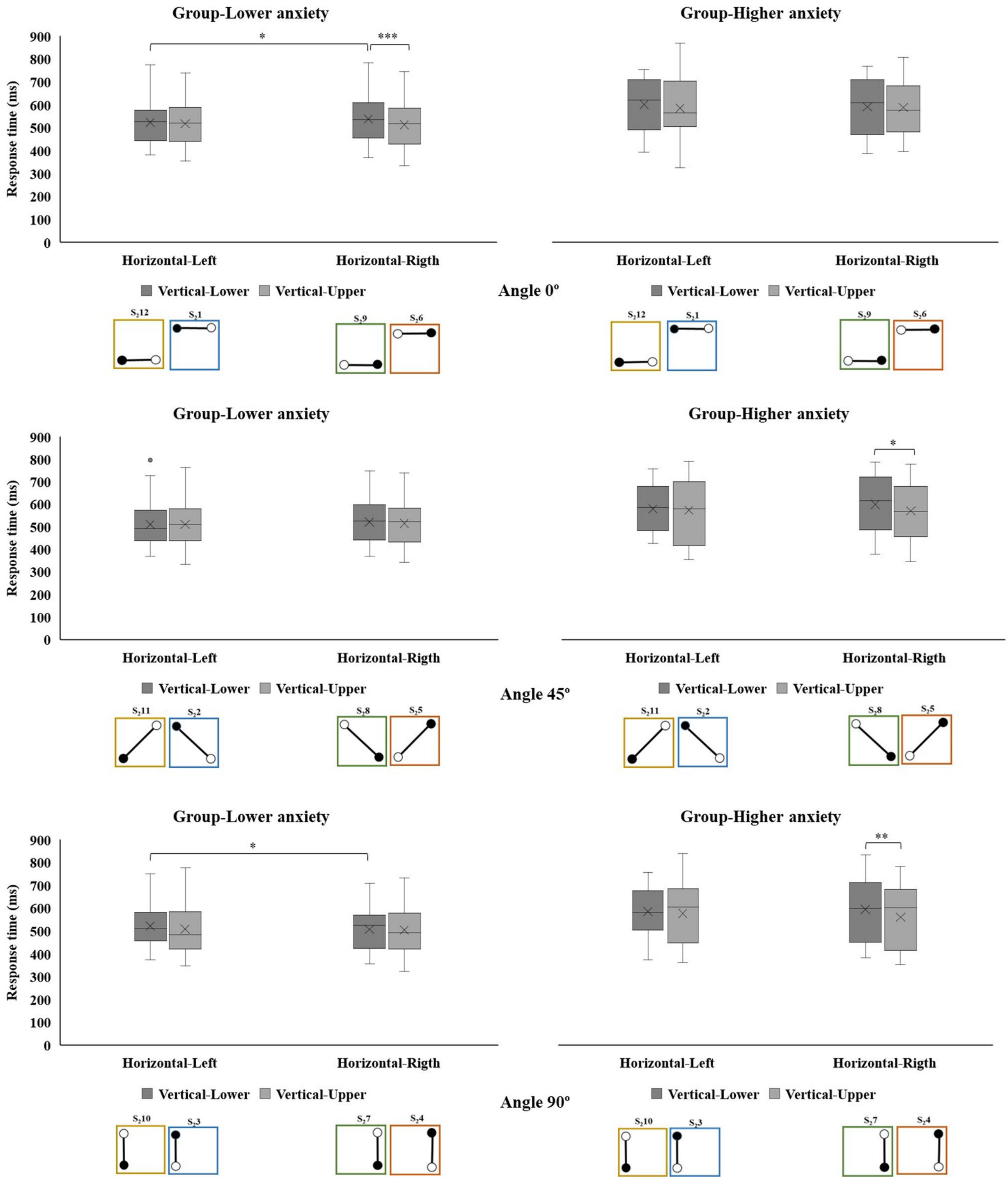

Fig. 4 Differences in RTs in the interaction of the variables Horizontal (left, right), Vertical (lower and upper half), Angle (0º,)

the different response systems (cognitive, physiological, and motor), and general trait anxiety. The hypotheses can be accepted, as those subjects with higher levels of cognitive anxiety responded more quickly to the sequences that began in the upper half (vs. the lower one); these differences were not observed in subjects with a lower level of cognitive anxiety (see Fig. 3). This effect has also been found in general trait anxiety, with a tendency

Table 5 Principal effects on trait anxiety of the variables Group, Horizontal, Vertical, and Angle

	F	p	η_p^2	P
Group	.00	.947	.00	.05
Horizontal	.90	.348	.02	.15
Vertical	8.46	.006	.15	.81
Angle	.12	.887	.00	.07
Group*Horizontal	.41	.525	.01	.10
Group*Vertical	10.81	.002	.19	.90
Group*Angle	.80	.453	.02	.18
Horizontal*Vertical	.05	.820	.00	.06
Horizontal*Angle	.67	.516	.01	.16
Vertical*Angle	1.00	.371	.02	.22
Group*Horizontal*Vertical	1.77	.190	.04	.26
Group*Horizontal*Angle	.05	.956	.00	.06
Group*Vertical*Angle	.33	.720	.01	.10
Horizontal*Vertical*Angle	.70	.497	.02	.17
Group*Horizontal*Vertical*Angle	.21	.808	.01	.08

to significance in the same direction as in physiological anxiety. These data are consistent with those reported in the study by Gordillo et al. (2020), in which the subjects responded faster to the sequences that began in the upper part of the face (vs. the lower one). The task is therefore reliable and sensitive to the different levels of cognitive, physiological, and general trait anxiety. Furthermore, subjects with lower levels of motor anxiety recorded shorter RTs in the sequences beginning on the upper right-hand side with an angle of 0º, compared to those beginning on the lower right-hand side. The same effect was observed in subjects with higher levels of motor anxiety, but with angles of 45º and 90º (see Fig. 4). These differences in the levels of motor anxiety regarding the angle at which the sequences began may be explained by the higher number of errors in the eye movements observed in people with high levels of anxiety (Hepsomali et al. 2016). This may be affecting attentional changes in horizontality (sequences with an angle of 0º), but not so much in verticality (sequences with angles of 45º and 90º). This finding is interesting because it shows that the angle at which the priming sequences are displayed could be a characteristic of those individuals with higher levels of motor anxiety (45º and 90º), as compared to those with lower levels of motor anxiety 0º). The relationship between the angle of presentation of the stimuli and attentional biases has been reported in some studies (Churches and Nicholls 2016), and in the case of anxiety, the data forthcoming in this research reveal that the level of motor anxiety has facilitating and inhibiting effects on RTs, which depend on the angle of the priming sequences. Nevertheless, no significant effects were found regarding levels of physiological anxiety, which may be explained by the low statistical power observed ($\eta_p^2 < 0.08$, $P < 0.46$) (H_2 is partially accepted).

The sequential priming task used has certain advantages over other kinds of techniques such as eye-tracking, which provide similar results, albeit with a higher application cost, being more inconvenient when administered to a clinical population. In other words, they require the participants to make a prior adjustment to the measuring instruments (eye-tracking glasses), which in some disorders (e.g., autism) could hinder their use. The proposed priming task could be applied to people with disorders that involve a deficit in the facial recognition and detection of emotions (Turner syndrome, Mazzola et al. 2006; epilepsy, Gomez-Ibáñez et al. 2014; autism spectrum disorders, Reisinger et al. 2020; specific behavioural disorders, Martin-Key et al. 2017; dementia, Hutchings et al. 2018), facilitating both diagnostic processes and rehabilitation, inasmuch as the task could be adapted to correct certain biases, prompting a suitable attentional response. As regards the diagnosis, and depending on the underlying disorder, certain priming sequences might either reduce or increase the response latency in emotional facial detection processes. Moreover, the task could be adapted to correct or mitigate attentional biases in anxiety disorders in order to improve inhibitory control, prognosis, and treatment efficacy (Barry et al. 2015). Some studies have already headed in this direction, proposing treatments designed to reduce cognitive biases though experimental tasks that require the rapid processing of information, such as Cognitive Bias Modification (CBM; Koster et al. 2009). Specifically, regarding anxiety disorders, gaze avoidance is a major limitation in the study of attentional biases, especially when the expressions are negative (avoiding the eye area), and which could even occur covertly (Kulke et al. 2016); the problem is mitigated, however, when more realistic methods are used (Claudino et al. 2019).

This would not be the case with the priming task because the subject processes the sequences subconsciously, whereby they would have an automatic attentional engagement effect. A possible modification of the task for reducing the attentional bias in people with high anxiety would involve presenting mixed priming sequences, where some of the four facial quadrants that constitute the sequence might be neutral or positive expressions. This procedure would be similar to the one used with the CBM technique. Strategies of this kind allow acting specifically upon a given cognitive bias, usually in an automatic and implicit manner (Koster et al. 2009). The advantage of the task proposed here involves the ability to select the priming sequences that specifically facilitate the detection of facial expressions of fear (attentional bias).

It may therefore be concluded that threatening facial expressions mainly attract the attention of people with high levels of anxiety. Specifically, it has been reported that attentional biases are a good predictor of the efficacy of treatment in anxiety (Barri et al. 2015). The development of therapeutic interventions designed to reduce NABs could have a positive effect on the treatment (Mobini and Grant 2007). This would be possible because the brain's attention networks allow controlling emotional networks, thoughts, and related behaviours (Ghassemzadeh et al. 2019). This is also congruent with the beneficial affects reported in the treatment of anxiety through mindfulness, leading to a reduction in the seriousness of the symptoms (Hofmann and Gómez 2017) through exercises that improve attention and increase inhibitory control (Eysenck et al. 2007).

The limitations here involve the number of subjects, which could affect the validity of the results. Nonetheless, statistically significant differences have been found despite the small sample and the medium levels of anxiety recorded, which prompts us to suggest that the task could be used on clinical samples. In turn, the variables age and gender have recorded differences in some of the comparison groups. These variables have been controlled for in the analyses, but future research should study how far they modulate the results. This is required because both age and gender have a clear influence on RTs in studies that have used different paradigms (Der and Deary 2006; Dykiert et al. 2012). Although the analyses conducted are within-subject, the design has used four independent variables in search of the interaction effects. It would also be convenient to use facial expressions without outside references, such as hair or clothing. Future research should analyse the processes for detecting other kinds of facial expressions (anger, happiness, sadness), with a view to establishing patterns of priming sequences that characterise each type of emotion, thereby enabling their application to different disorders linked to attentional biases (e.g., depression-sadness, eating disorders-disgust). It would also be expedient to study the effect that the comorbidity between anxiety and depression has on the attentional biases recorded in the priming task. Finally, the modulating effect of the priming's display time needs to be investigated, as does the possibility of adjusting the task to require the subjects to distinguish between two emotions, with the aim being to force the preference for certain kinds of sequences that favour the response's efficacy.

To conclude: (a) the 24-sequence priming task is reliable because it obtains similar results to those reported by Gordillo et al. (2020). Both studies record shorter RTs for those sequences beginning in the upper part of the face (vs. the lower part); (b) the task is sensitive to differences in the levels of cognitive anxiety and general trait anxiety; (c) the task's reliability and sensitivity mean it can be used on a clinical population, with different disorders involving attentional biases; and (d) the 24 priming sequences can accurately identify different disorders, facilitating their diagnosis and treatment (modification of the attentional bias).

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