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Sex differences and personality in the modulation of the acoustic startle reflex

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ABSTRACT

The modulation of the eyeblink component of the acoustic startle reflex (ASR) has been used to study human motivation, attention, and emotion towards affective stimuli of different valence. However, sex and individual differences in personality have been rather overlooked concerning the change in the ASR to brief affective sequences. In this study, we aimed to evaluate sex differences in the ASR, together with the influence of sensitivity to punishment (SP) and sensitivity to reward (SR) in the affective modulation of the ASR to pleasant and unpleasant pictures. We addressed this topic with a latent curve model (LCM) representing the change in the ASR of an extensive group of men (n = 166) and women (n = 109). There was a significant habituation of the ASR to the pleasant pictures, and a significant sensitization of the ASR to the unpleasant pictures. Both effects were higher and more variable for women than for men. There were in addition interactive and quadratic effects of SP and SR on the ASR to the pleasant and unpleasant pictures. Men and women with extreme scores in SP, and women with low scores in SR habituated faster to the pleasant stimuli. For men scoring low in SP, higher scores in SR related with an attenuated initial ASR to the unpleasant stimuli. Women with extreme scores in SP had a higher initial ASR to the unpleasant stimuli. There were remarkable asymmetries between men and women concerning personality effects on the change in the ASR to affective stimuli.

1. Introduction

The modulation of the eyeblink component of the acoustic startle reflex (ASR) is a compelling paradigm to address motivation, attention, and emotion [12]. The ASR is a defensive automatic response to a sudden event involving the involuntary movement of muscles, which is inhibited under appetitive stimuli and potentiated under aversive stimuli ([4]; A. [7, 10, 42]). Sex differences arise in the acoustic startle reflex (ASR) in animals, with females generally showing higher responses [46]. In humans, men are more reactive to pleasant stimuli, and show more reduced ASR amplitudes compared to women. In contrast, women are more reactive to unpleasant stimuli, and show more augmented ASR amplitudes compared to men [11, 12, 27].

This disparity between men and women in the affective modulation of the ASR can be due to sex differences in the brain activation, processing, and neural correlates of emotions [28, 39, 61, 64]. Moreover, menstrual cycle and oral contraceptives intake contribute to meaningful differences in the ASR between men and women. For instance, women show increased ASR during the late luteal phase and during ovulation [3]. Besides, the ASR is lower in a prepulse inhibition paradigm for males and for women taking oral contraceptives [37]. However, sex differences in self-reported personality have received much less attention, even though they might contribute as well to explaining the distinct ASR of men and women. Women tend to score higher than men in big five traits such as neuroticism, agreeableness, and conscientiousness [55]. Moreover, and in accordance with traits derived from the reinforcement sensitivity theory of personality (RST), women also tend to score higher than men in anxiety and fear, but lower than men in impulsivity [15, 20, 50, 56].

The RST is particularly pertinent to study individual and sex differences in the ASR. The RST and further extensions of the theory propose that behaviour emerges from the interplay between three main systems [29, 30]. The behavioural approach system (BAS) is sensitive to signals of unconditioned and conditioned reward signals and is the basis for impulsivity and extraversion. The behavioural inhibition system (BIS) is sensitive to signals of punishment and is the basis for

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anxiety and neuroticism. The fight-flight-freeze system (FFFS) is also sensitive to conditioned and unconditioned signals of punishment and is the basis for fear. Emotional and motivational processes elicit sensitivity to punishment when mediated by the BIS and FFFS, albeit elicit sensitivity to reward when mediated by the BAS [57]. The separable and joint subsystems hypotheses enunciate the equilibrium of sensitivity to punishment (SP) and sensitivity to reward (SR). The separable subsystems hypothesis predicts similar responses to appetitive stimuli at all levels of SP, and similar responses to aversive stimuli at all levels of SR. The joint subsystems hypothesis predicts a SP × SR interaction whereby SP facilitates responses to aversive stimuli and antagonizes responses to appetitive stimuli, and SR facilitates responses to appetitive stimuli and antagonizes responses to aversive stimuli. However, the revised RST conceptualizes fear and anxiety as separate but intermingled processes, matching different personality factors [17, 51, 58].

Several studies relate the RST traits with the habituation of the ASR (A. [6]; A. [8, 45]), and with the ASR to affective stimuli [2, 13, 16, 19, 36]. Nevertheless, there is a paucity of studies combining the association of sex and individual differences in personality with the affective modulation of the ASR [12, 34]. Sex differences in personality are remarkable regarding the valence, intraindividual variability, and rate of change of emotional experiences sampled on a daily basis [25], while startle affective modulation also depends on temporal factors associated with the presentation of emotional stimuli [23]. For instance, women show a higher ASR than men do in sustained anxiety compared with phasic fear conditions [31]. Moreover, women display a higher sensitization to unpleasant stimuli even after stimuli offset [27]. Therefore, sex and individual differences in personality influence the temporal change of the affective modulation of the ASR.

The latent curve model (LCM) is an adequate approach to evaluating changes in repeated psychophysiological measures, while it can incorporate crucial predictors of these changes [40, 41]. In the current study, we used a LCM to characterize sex differences in the ASR to affective stimuli of a varying valence, and to examine the concomitant influence of individual differences in sensitivity to punishment (SP) and sensitivity to reward (SR). The study had two major goals. First, we assessed whether there were sex differences in the change of the ASR when viewing sequences of pleasant and unpleasant pictures selected from the International Affective Picture System, IAPS [43]. In accordance with past research [11, 12, 27], we expected habituation effects for the pleasant pictures, and sensitization effects for the unpleasant pictures, with men displaying a higher habituation than women, and women displaying a higher sensitization than men.

Second, we studied whether individual differences in SP and SR for both sexes modulated the reactivity to pleasant and unpleasant affective pictures. On the one hand, men tend to score lower than women do in SP and related traits, whereas women tend to score lower than men do in SR and related traits [20, 55]. On the other hand, SP relates with a potentiated ASR to unpleasant and fearful stimuli [13, 19], whereas SR relates with a potentiated [2] and pre-pulse inhibition [36] of the ASR to pleasant stimuli. Therefore, we expected that SR in men should modulate the change in the ASR for the pleasant stimuli, whereas SP in women should modulate the change in the ASR for the unpleasant stimuli. In addition, we contrasted whether there was more support for either the RST separable or the joint subsystems hypotheses by examining interaction and non-linear terms of SP and SR [17, 51, 58].

2. Method

2.1. Participants

There were 178 male and 163 female undergraduate students from different disciplines collaborating in a study about startle reflex and personality. Participation was voluntary and economically encouraged with 15€. All of these participants provided a written informed consent and went through the procedures described here, after the ethical committee of our University had approved the study, which was carried out in accordance with the declaration of Helsinki. However, the data analyses were constrained to individuals selected in accordance with two main criteria. First, forty females (25% from the female participants) who were in the menstrual days of their cycle or had been using oral contraceptives were removed from the data analyses because of the influence of hormones on emotional reactions [3, 37]. Second, twelve males (7% from the male participants), and fourteen females (9% from the female participants) were removed because of either zero or extreme ASR responses on three or more trials [9]. This selection resulted in a sample of 166 males and 109 females. Males age ranged between 17 and 55 years old (M = 22.23, Sd = 4.19), females age ranged between 18 and 44 years old (M = 21.12, Sd = 3.60). Mean ages between males and females were significantly different ($t = 2.27$, $df = 273$, $p < .05$).

2.2. Emotional stimuli

There were forty five pictures selected from the International Affective Picture System (IAPS) [43], with fifteen pictures of pleasant, neutral and unpleasant valence. In accordance with the aims of the study, we selected the data from the pleasant and unpleasant pictures only. The pictures were arranged in a random sequence such as no more than two pictures of the same valence were presented consecutively. The pictures were presented to the participants on a 32-in monitor placed about 120 cm from the participant. There was a fixed inter-trial interval of 10 s between pictures, and each picture was visible in the monitor for 5 s. Startle probes were present on ten out of the fifteen pictures of each valence, and delivered binaurally trough headphones at random times of either 2, 3, or 4 s after the picture onset. Startle probes were 50 ms bursts of broadband noise with instantaneous rise time and calibrated at 105 dB (A). Every picture was presented in the same order and with the same delay of the startle probe for all participants.

In the current study, we analyzed only the pleasant and unpleasant pictures. Because categories of pictures within a single valence may elicit higher responses for either men or women [54, 60], we selected pictures shown to have minimal sex differences in the ASR [11, 12]. These were six pictures of each valence including contents of action and adventure for the pleasant pictures, and accidents and mutilations for the unpleasant pictures. Table 1 shows the arranged sequence of the twelve pictures. In accordance with normative IAPS data [49], pictures were very similar for males and females ($d \leq 0.4$) in average valence and arousal [14].

2.3. Physiological and self-reported measures

Physiological data were acquired with electromyographic (EMG) recordings to the startle probes associated with each picture. The eyeblink component of the ASR was measured with two 6 mm silver chloride (*AgCl*) cup skin surface electrodes filled with conductive paste. These two electrodes were placed below the lower left eyelid in line with the pupil separated by 15–20 mm, with an additional signal ground electrode placed at the forehead. With binaural stimulation, there are no laterality effects. In addition, impedances were controlled to be below 5 kΩ [9]. The EMG signals were recorded with the Biopac MP100 hardware and the AcqKnowledge software at a sampling rate of 1000 Hz amplified with a gain of 5000. There was an on-line passband filter at 23–500 Hz, and the data was rectified and smoothed offline over an average of five data points.

Personality was assessed with the short version of the sensitivity to punishment and sensitivity to reward questionnaire [1]. This instrument comprises 20 items with 10 items per scale: Sensitivity to Punishment (SP) and Sensitivity to Reward (SR). For the current data, the SP and SR test-retest reliabilities were 0.78 and 0.72 for males, and 0.81 and 0.80 for females. Males scored lower than females in SP ($t = 2.26$, $df = 273$, $p < .05$), and higher than females in SR ($t = 3.07$, $df = 273$,