Contributions to the Cognitive Study of Facial Recognition on Down Syndrome: A New Approximation to Exploring Facial Emotion Processing Style

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Abstract: *Background*: This paper aimed to explore the ability of people with Down syndrome (PWDS) in recognizing facial emotion by considering automatic cognitive processing levels of face recognition.

Method: A sample of PWDS and participants with typical development (PWTD) participated in a set of two affective priming studies. In each study, participants had to categorize an emotional or neutral target face that was preceded by another emotional face. Stimuli presentation for each facial set (one face after another) was conducted by using an stimulus onset asynchrony (SOA) of 300 ms with the inter-stimulus interval (ISI) set at 50 ms. The first affective priming study manipulated emotion congruency between prime and target emotional faces to explore emotion classification abilities and to identify the cognitive mechanisms underlying automatic recognition of some emotional faces. The second study explored the effect that gender of a face has over categorization of facial emotion and difficulty in recognizing negative facial expressions.

Results: The results strongly suggest that not all of the PWDS present difficulties in recognizing negative facial emotions. PWDS' performance pattern in categorizing emotion was similar to that of PWTDs if they had to use broad classification categories (e.g., emotion vs. no emotion). However, differences between both samples occurred if PWDS had to use a specific category task (e.g., classification of happiness, sadness, etc.).

Conclusions: At least two emotion information processing styles can be identified in PWDS. Methodological and theoretical implications for exploring the emotional capabilities of people with DS are discussed.

Keywords: Down's syndrome, emotional facial recognition, affective priming paradigm, emotion appraisal, cognitive mechanisms.

The recognition of facial emotion is a valuable skill in social interaction. Since the early ages of evolution, humans have the ability to recognize faces that are expressing emotions from those that are not (neutral). We can also discriminate between facial expressions displaying different emotions (happiness, sadness, etc.). This capacity empowers the human race to obtain meaningful inferences about what others are experiencing as well as to predict the behavior of others [1]. However, little is known about this cognitive process in people with Down syndrome (PWDS). Most research on this matter has been centered on autism and other intellectual disability (ID) etiologies [e.g., 2], and only a small set of studies on this topic related to DS can be acknowledged [e.g., 3-7].

Overall, research in this field suggests that persons with DS have some facial emotion recognition difficulties. For instance, regarding identity matching tasks using faces, young PWDS are less accurate in recognizing emotional faces than typical children with the same mental age, as well as children and adolescents with the same mental age having another intellectual disability [8, 7]. Specifically, it has been observed that children with DS have more problems recognizing fear and surprise [6]. Another study also emphasized PWDS' difficulties in recognizing negative faces [5], and suggested that people with this genetic condition have a different information processing style that is tuned to discriminate angry faces [9].

On the other hand, it has been suggested that neural processing regarding facial emotion recognition changes with age [10]. However, to our knowledge, no research on how facial emotional recognition changes with age in PWDS are currently available. Certainly, it is not clear if the recognition difficulties with negative faces observed in children and adolescents with DS can be generalized to adults of the same population. In addition, it is unclear if difficulties in recognizing negative emotions in faces at early ages in PWDS endure into adulthood.

Morales and Lopez [11] have suggested, for the first time, the use of affective priming studies to address

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these concerns. This methodological approach has been useful in exploring how people's appraisal mechanisms change with time as well as in studying personal differences in emotional appraisal [1].

It is also worth mentioning that a typical affective priming study identifies how the emotional valence of a stimulus (prime) affects the recognition of the emotional valence of another stimulus (target) [12]. This affective behavior where the presentation of an emotional stimulus might facilitate or interfere with the emotional recognition of another is called the *affective priming effect* [13, 12, 14].

The affective priming effect has been demonstrated *via* a wide variety of stimuli such as pictures of animals, odors, and drawings [see 15-17]. Among the strongest affective priming effects are those that are visual [18-20]. Emotional faces as stimuli are particularly effective, as this visual information has ecological validity due to their relevance in social interactions and social communication [21]. Moreover, facial stimuli are very suitable for people who have difficulties in reading (e.g., some people with ID).

On the other hand, the affective priming technique has been used to explore emotional phenomena through a wide set of populations that include adults, teenagers, and children with or without emotional disorders [e.g., 1, 13, 22, 23]. However, it was not until recently that this experimental paradigm has been used to explore PWDS' emotional system [see 24]).

Initial research on affective priming and participants with intellectual disability was conducted by Morales [25, 26] and Morales and Lopez [10]. Specifically, a set of pilot studies presented by Morales [25] and Morales and Lopez [10] tested the ability of four PWDS´s in classifying emotional faces (positive and negative) and non-emotional faces by using an affective priming approach. Here, participants were presented with experimental trials on the computer screen, with each trial consisting of two faces presented consecutively. The experimental task was to indicate whether the second face of each pair expresses an emotion. The results suggested that most PWDS wrongly recognized negative facial information, which revealed difficulties in processing and recognizing negative emotion. This was not the case for the typical population assessed in the study. This result differs if controlled cognitive processing is considered as suggested in the second pilot study. Here, the participants' task was to decide which of two faces (left or right) that were presented simultaneously on a computer screen was substituted by a point.

These two initial studies included facial stimuli from different cultural contexts (emotional faces were obtained from Ekman, Freisen, and Hager [27]). This might have affected recognition thresholds (a familiarity factor) [28]. Interestingly, follow up studies [24, 26] found evidence that not all participants with DS have difficulty recognizing negative facial information from their own cultural context (two out of 12 correctly recognized all negative targets). These results suggest that PWDS' improper automatic appraisals of emotional facial information cannot be generalized to the entire population with this condition.

In a follow up study, Morales and Lopez [29] implemented an affective priming study where the familiarity of faces was manipulated. The study goal was to explore if familiarity to the faces of people with DS (in contrast to typical faces) affects the recognition of positive and negative facial information in PWDS. The authors found significant differences in recognition between positive familiar faces and positive non-familiar faces. In addition, some participants with DS did not have difficulty categorizing negative non-familiar faces but had difficulty categorizing familiar negative faces as emotional or non-emotional faces.

Some questions have emerged from these results. For instance, do PWDS who are able to recognize negative faces have the same facial recognition processing style as PWTD? Furthermore, it is necessary to expand our comprehension about the nature of the cognitive processing mechanisms underlying PWDS' difficulties in recognizing negative information, e.g., to determine if these difficulties apply to all spectra of negative facial display, and if gender differences are relevant. With regard to the last aspect, some studies have suggested that the gender of a study participant [30] as well as the gender of the facial stimuli [31] affect the recognition of facial emotions. In particular, it has been observed that women outperform men at recognizing positive facial emotions when the recognition task requires automatic processing [30]. However, it is not known if these gender differences apply to PWDS.

A set of experimental studies exploring some of these inquiries are described next.

METHOD

A set of affective priming studies were implemented to introduce the Human Information Processing (HIP) approach as a new complementary and insightful way to explore how people with DS recognize facial emotion information. This type of experimental studies is useful for identifying emotion classification difficulties as well as emotional preferences toward a wide spectrum of stimuli ranging from social events from different populations to pure perceptual information. However, not much is known about this subject when considering the cognitive emotional behavior of PWDS; thus, much needs to be learned in this aspect. Initial research in this regard is introduced next.

Experiment 1: Automatic Processing and Classification of Emotion Face Recognition

This study sought to explore automatic emotion information processing that underlies categorization difficulties in facial emotion information. Specifically, the study aimed to extend the current literature on difficulties in PWDS in properly categorizing negative facial information [see 24].

Design

Two experimental factors were considered in this study. First, the type of groups to sample (PWDS vs. PWTD) and types of relationship between facial emotion stimuli (emotionally congruent face pairs: positive-positive, negative-negative, and neutral-neutral; and emotionally incongruent pairs: negative-positive, positive-neutral, negative-neutral, and neutral-positive). Reaction time i.e., the time taken to classify target emotion faces (second face of a pair of emotion faces) was the dependent variable.

Participants

Twenty-one PWDS (nine women and 12 men) constituted the experimental group. Their ages ranged between 15 and 48 years (M = 28). The control group consisted of 21 PWTD (13 women and eight men) whose age ranged from 17 to 40 years (M = 21). All of the participants lived in a city located in the north of Mexico.

Participants' cognitive abilities were evaluated *via* the Wechsler scale (WAIS-III or WISC-IV). However, the inclusion or exclusion of participants was not only dependent on their IQ scores. Participation in the study was voluntary without economical reward.

Instruments and Materials

A set of 18 facial stimuli (six positive, six negative, and six neutral faces) were selected from a digital database of Mexican faces called BE-FACE [1]. The faces were arranged in pairs (prime-target) to create 135 experimental trials. Trial presentation factored in temporal aspects. Each trial presented the two faces consecutively, and stimulus onset asynchrony (SOA) was controlled, i.e., the time interval considering the beginning of the presentation of the first stimulus up to the beginning of the presentation of the second stimulus. In addition, the inter-stimulus interval (ISI; time between both stimuli) was controlled. Manipulation of the ISI and the SOA induces either cognitive automatic processing or controlled processing. In this study, both temporal parameters were set to activate automatic processing. The experimental trials were presented on a computer using the software Super Lab Pro 5.

As indicated previously, Wechsler scales **(**WAIS-III or WISC-IV) were used to test participants' IQ. Moreover, an instrument was developed (Multidimensional Assessment of Emotion—I: MAE-1) to capture demographic information (age, gender, health, etc.), mood history (possible emotional disorders, current mood states, most frequent mood state), and measurement of emotion dimensions (conceptualization, experience, self-regulation, and perceived emotion, as well as face recognition capacities: emotion naming, emotion identification, emotion discrimination, etc.).

Procedure

Informed consent was obtained from all participants. In addition, approval was obtained from the institution where the PWDS attended for educational purposes. Each participant attended individual study sessions where verbal and written instructions on how to proceed through the study were provided. After the practice trials followed the 135 experimental trails. Participants were seated in front of a computer. Each experimental trial first presented a dot at the center of the computer screen to center participants' gaze. Then, facial prime-target pairs were presented with an ISI of 50 ms and SOA of 300 ms. The experimental task was to indicate through a key on the keyboard if the facial targets contained emotional content or not (emotion vs. no emotion) (see Figure **1**).

First Study Results

Three statistical analyses were conducted with pooled correct answers. For participants' data to be included in the analysis, they should have had at least

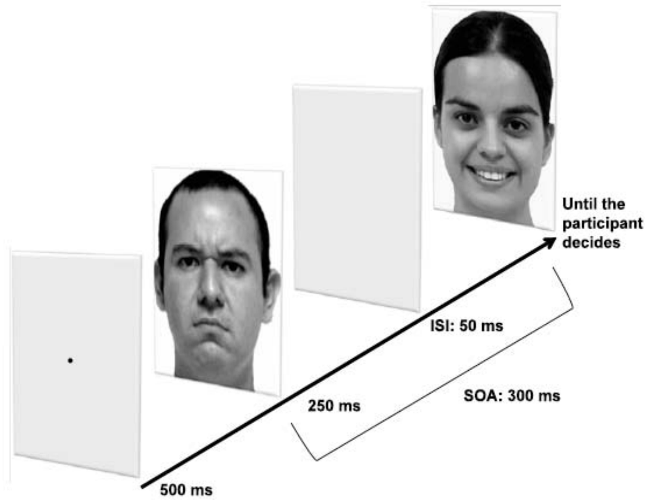


Figure 1: Illustration of an affective priming experimental trial.

60% of correct hits. First, a 2 (PWDS vs. PWTD) × 6 (positive/positive, positive/neutral, negative/neutral, neutral/neutral) mixed ANOVA was performed on data from 39 participants (PWDS = 18; PWTD = 21). Here, only six out of the nine experimental conditions were analyzed because only three out of the 21 PWDS correctly answered in experimental conditions where the target was negative.

There was a significant main effect of group. As expected, PWDS were significantly slower than the control group in all experimental conditions, $F(1,37) = 38.03$, $p < .001$, $\eta^2_p = .50$. This result could be more related to the cognitive condition than emotional style. In addition, a significant main effect was obtained for type of emotion relation between faces, $F(5,185) = 7.52$, $p < .001$, $\eta^2_p = .16$.

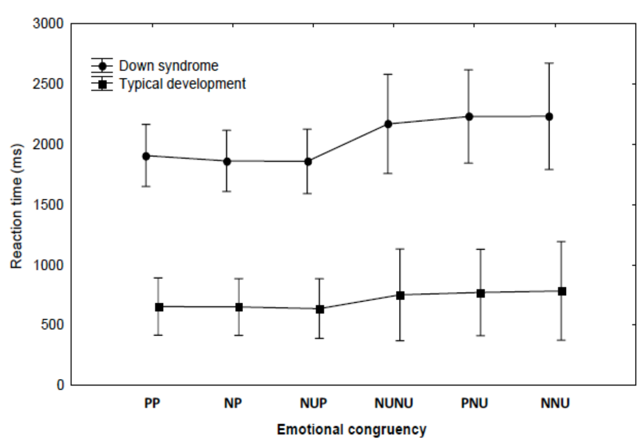


Figure 2: Interaction graphs for each analysis shows both groups' performance on incongruent emotion relation (recognition latencies to negative targets were not considered) and positive congruent recognition (data analysis was performed a mixed 2 × 6 ANOVA).

Notice from Figure **2** that a non-significant interaction effect was obtained for group and emotion incongruency between faces. The emotion recognition data pattern seems to be similar for both study samples.

A second analysis was carried out to compare the data pattern of three PWDS, who were able to recognize negative information, with the recognition performance of three PWTD. A 2 (DS vs. TD) × 3 (positive/positive, negative/negative, neutral/neutral) mixed ANOVA showed a statistically significant main effect of group, $F(1,4) = 68.77$, $p < .001$, $\eta^2_p = .94$. Specifically, the experimental group was significantly slower than the control group in all experimental conditions. The analysis also revealed a significant effect across the nine experimental conditions, $F(8,32) = 11.32$, $p < .001$, $\eta^2_p = .73$. Furthermore, a significant interaction effect was obtained for group and emotional congruency $F(8,32) = 9.27$, $p < .001$, $\eta^2_p = .69$. This indicates that emotional congruency and group did not have similar effects over participants' performance for all experimental conditions (Figure **3**).

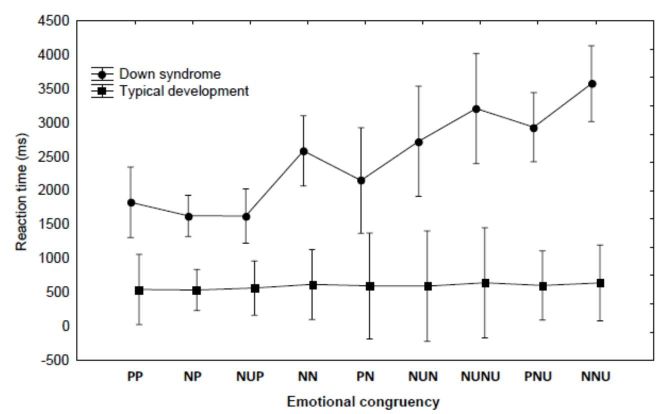


Figure 3: Interaction graphs for each analysis showing both groups' performance to incongruent emotion relation (the mixed 2 × 9 ANOVA included only the reactions times of three PWDS who recognized negative targets).

To compare the performance of PWDS who recognized the negative target (three participants) with those who did not (18 participants), a final 2 × 6 mixed ANOVA was conducted. We found a significant effect for emotional congruency, $F(5,95) = 17.38$, $p < .001$, $\eta^2_p = .47$. The main effect of group was not significant, $F(1,19) = .53$, $p < .47$, $\eta^2_p = .02$. This result might be related to PWDS' high performance variability in the recognition of negative targets, as shown in Figure **4**. It is interesting that performance in both groups was similar for only the positive target condition and not neutral target conditions.

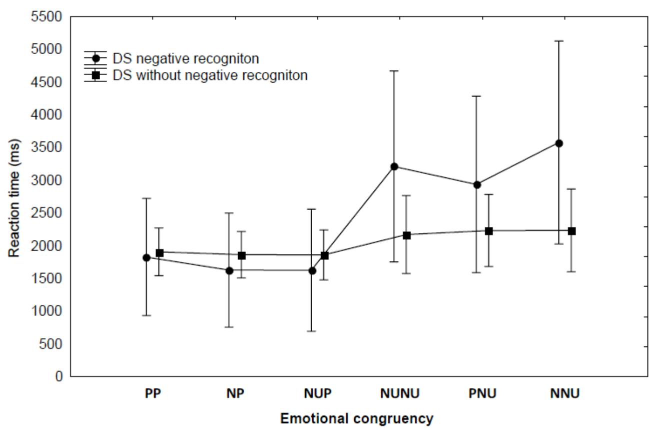


Figure 4: Interaction graphs for each analysis showing both groups' performance in incongruent emotion relation (the 2 × 9 mixed ANOVA included only the reaction times of three PWDS, who recognized negative targets, and three PWTDs).

Experiment 2: Detection of preferences

The above study sought to explore automatic emotion processing of three sources of information (positive, negative, and neutral). The results showed that some participants with DS were able to classify negative information. However, the emotion spectrum they had to identify was very limited. Therefore, in this study, this problem was solved by introducing a wider emotion spectrum that allows more specific analysis on the capacity of PWDS in recognizing facial emotion information.

Design

Again, the type of emotion relation factor was considered. Here, emotion congruency included six emotion categories (happiness, surprise, fear, anger, sadness, and neutral). These categories lead to 36 emotion combinations (happiness-happiness, happiness-surprise, happiness-fear, etc.). Face gender (male, female) was also considered, as well as type of population (DS vs. typical individuals). The time taken for categorization (reaction time) was the dependent variable.

Participants

This first study considered a sample of 61 participants, where 51 were PWTD (40 women and 11 men) with an average age of 20 years (SD = 5). The ten other participants consisted of PWDS. This sample had an average age of 28 years (SD = 10). All participants verbally agreed to voluntary participation without economic remuneration and debriefing was provided to all of the participants as well as to parents and caregivers. As in the first study, cognitive measurement was administered to participants.

Materials

In this study, ten different faces were considered, each displaying six different emotions (happiness, surprise, fear, anger, sadness, and neutral). In total, 60 emotional and non-emotional faces (30 male and 30 female faces) were selected from a digital database of faces named BE-FACE I. These faces were combined to obtain 360 prime-target pairs (ten different combinations for each experimental condition. For instance, ten female and ten male face pairs with a happy-happy combination). These combinations were used as experimental trials in the study. Experimental time parameters consisted of an SOA of 300 ms and an ISI of 50 ms.

The Wechsler scale **(**WAIS-III or WISC-IV) was used to measure participants' cognitive abilities. The Multidimensional Assessment of Emotion-I (EME-I) was also administered to obtain the demographic and emotional profiles of participants.

Procedure

The same procedure from the previous study was used in this third study. Participants were tested individually in an emotion categorization task. First, verbal instructions were provided to the participant, followed by a practice session. Once the participant was ready, she/he proceeded with the experimental trials. The experimental trials were randomly presented. Each trial consisted of presenting a dot at the center of a computer screen followed by an emotional or non-emotional face for 250 ms (prime), a blank of 50 ms (ISI), and the second face (target displaying emotional content or not), in this order. This last face remained until the experimental task was completed. Temporal parameters were set up for an SOA of 300 ms and an ISI of 50 ms (see Figure **5**).

Second Study Results

This study sought to explore, with more specificity, the processing style of PWDS regarding gender and specific emotion categories (happiness, anger, sadness, etc.). To do so, the reaction times of 51 PWTD and five PWDS who did not properly categorize negative information were analyzed in a 2 (group: PWDS vs. PWTD) × 2 (gender: female vs. male) × 2 (emotional congruency: positive-positive vs. neutral-neutral) mixed ANOVA. The results revealed a

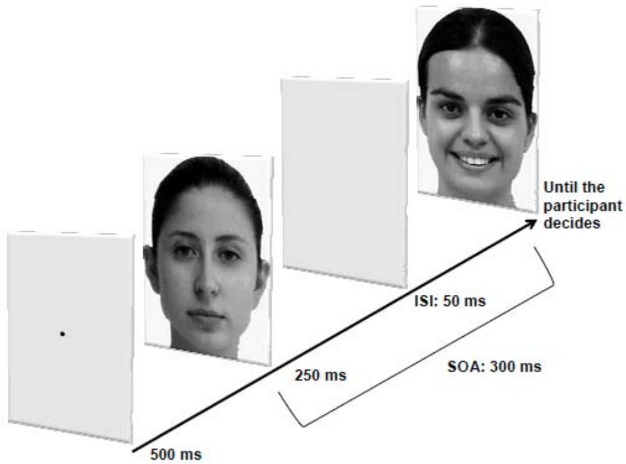


Figure 5: Sequence of events of an experimental trial in the emotion categorization study.

significant main effect of group, $F(1,54) = 75.93$, $p < .001$, $\eta^2_p = .58$. Again, the cognitive condition is presumed to affect reaction time. No main effect of gender, $F(1,54) = .002$, $p = .96$, $\eta^2_p = .00003$, nor emotional congruency, $F(1,54) = .04$, $p = .83$, $\eta^2_p = .007$, was obtained. However, a separate analysis showed no significant main effect of emotional congruency for only PWDS, $F(1,4) = 0.26$, $p = .63$, $\eta^2_p = .06$; a significant main effect was found for PWTD, $F(1,50) = 63.53$, $p < .001$, $\eta^2_p = .56$. Moreover, a significant main effect for face gender was found for the PWTD group, $F(1,50) = 14.62$, $p < .001$, $\eta^2_p = .22$. This was not true for the PWDS group, $F(1,4) = 0.09$, $p = .77$, $\eta^2_p = .02$.

This difference was not maintained when comparing the five PWDS capable of categorizing negative faces with the 51 PWTD group in a 2 (group: PWDS vs. PWTD) × 2 (face gender: female vs. male) × 3 (emotional congruence: positive-positive, negative-negative, neutral-neutral) mixed ANOVA (Figure **6**). The results showed a main effect of group, $F(1,5) = 115.47$, $p < .001$, $\eta^2_p = .68$, face gender, $F(1,53) = 23.60$, $p < .001$, $\eta^2_p = .30$, and emotional congruency $F(2,106) = 33.64$, $p < .001$, $\eta^2_p = .38$.

Notice that both groups required less time to evaluate positive faces than negative and neutral faces. It is interesting to observe here that PWDS had an evaluation pattern different from that of PWTD (see performance differences in Figure **6**). Interestingly, PWDS required more time to evaluate positive female faces than to evaluate male faces. This was not the case for PWTD.

The analysis of face gender in emotional categorization could be conducted on only the PWTD group because PWDS who correctly classified negative faces did so over different types of negative facial emotion content (see Figures **7** and **8**). Figure **8** exemplifies PWDS' performance variability in categorizing negative information.

Overall, note from Figures **7** and **8** that PWDS seemed to have major difficulties categorizing faces displaying fear, anger and sadness. This is interesting, since a set of analytical comparisons of the performance of 50 PWTD across the experimental conditions showed that gender differences appeared only when comparing the recognition of female faces showing fear with male faces showing fear, $F(1,45) = 4.19$, $p < .04$, or when angry faces were considered, $F(1,45) = 5.93$, $p < .01$.

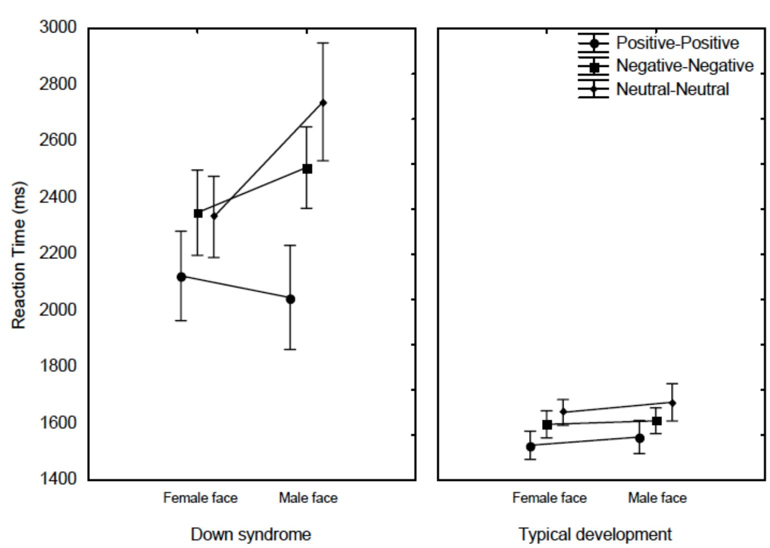


Figure 6: Interaction graphs for face gender, emotional congruency, and group (PWTD vs. PWDS who recognized negative targets as an emotion).

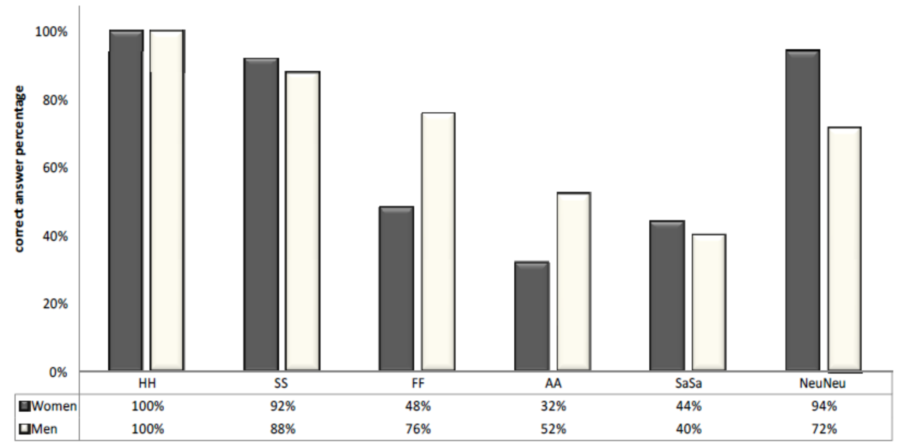
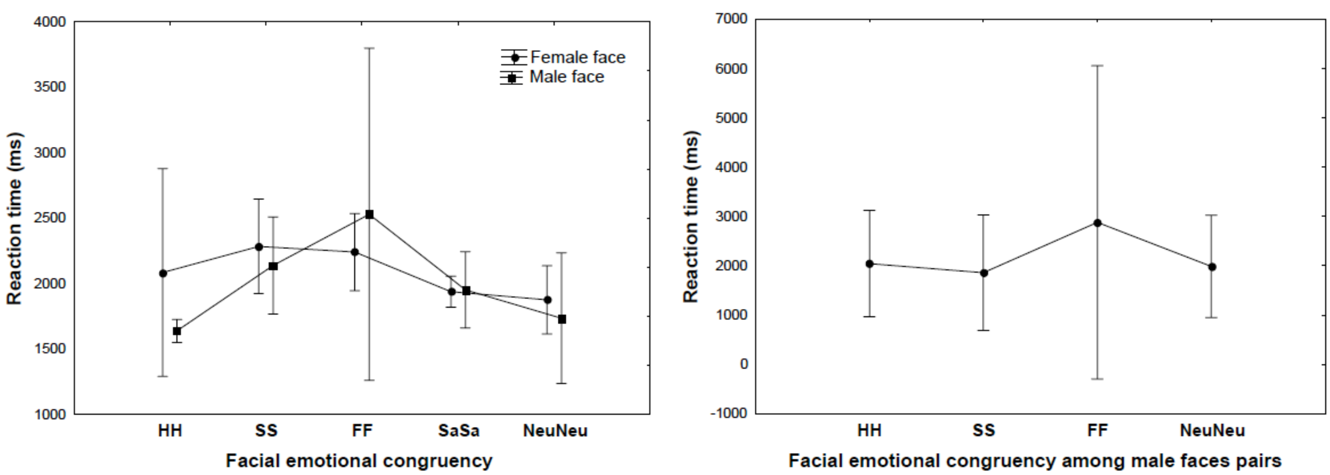


Figure 7: Graph depicting the percentage of PWDS' correct emotion recognition by face gender (female vs. male) for the experimental conditions of happiness-happiness (HH), surprise-surprise (SS), fear-fear (FF), anger-anger (AA), and sadness-sadness (SA-SA).



A **B**

Figure 8: Example of a data pattern for two male PWDS. The interaction graph for the first participant shows that he was able to correctly categorize all experimental conditions containing a negative target (Panel **A**), while the second participant recognized only some negative male face targets (Panel **B**).

DISCUSSION

This study explored the abilities of PWDS and PWTD in recognizing facial emotion information. As expected, in both studies, a considerable portion of the PWDS sample had difficulty recognizing negative information (18 out of 21 in the first study and five out of ten in the second study). Note, however, that not all members of this group had this difficulty. This is consistent with previous studies reporting that some PWDS are capable of recognizing negative facial content [25].

In addition, the results suggest that within the PWDS population, variability can be observed regarding the information processing style of emotions, similar to in PWTD. For instance, both studies showed at least two different ways of processing emotional information. The first included PWDS who showed difficulties in recognizing negative information and the second included PWDS who were able to correctly classify negative information if the categorization task required only emotional categorization (Figure **4**). The first group PWDS group performed similarly to the PWTD group (Figures **2**), but the second PWDS group did not. Specifically, the second PWDS group had higher latencies than the PWTD group to evaluate negative targets (Figure **3**). This suggests that emotion appraisal mechanisms differ for the evaluation of specific dimensions such as emotion intensity or the particular meaning of an emotion. It is, however, unclear if this is the case, and more research is required regarding this topic.

Another interest of this study was to determine to what extent difficulty in recognizing negative emotions apply over the negative emotion spectrum. With regard to this, the second study showed that participants who were capable of recognizing negative emotions did not necessarily extend this ability to the entire spectrum of negative emotions presented in this study. This is the case for some participants who showed more difficulties to categorize faces of anger and fear (mainly female faces), whereas some other participants had recognition difficulties over sad faces (Figures **7** and **8**).

The emotion research presented up to here is relevant for several reasons. First, this academic effort constitutes the first attempt at introducing the affective priming paradigm to explore the facial emotion recognition of PWDS. This provides a new direction with which to explore how members of this population process emotions. This in turn would lead to a deeper understanding of the emotional world of PWDS and empower us to help them.

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