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Differential outcomes, schizotypy, and improvement of the recognition of emotional facial expressions: a preliminary study

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Schizotypy is defined as a combination of traits qualitatively similar to those found in schizophrenia, though in a minor severity, that can be found in the nonclinical population. Some studies suggest that people with schizotypal traits have problems recognising emotional facial expressions. In this research, we further explore this issue and we investigate, for the first time, whether the differential outcomes procedure (DOP) may improve the recognition of emotional facial expressions. Participants in our study were students that completed the ESQUIZO-Q-A and were set in two groups, high schizotypy (HS) and low schizotypy (LS). Then, they performed a task in which they had to recognise the emotional facial expression of a set of faces. Participants of the HS group and the LS group did not differ in their performance. Importantly, all participants showed better recognition of emotional facial expressions when they were trained with differential outcomes. This novel finding might be relevant for clinical practice since the DOP is shown as a tool that may improve the recognition of emotional facial expressions.

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The schizotypal personality disorder (American Psychiatric Association, 2013), is characterized by ideas of reference, odd beliefs inconsistent with subcultural norms (e.g., telepathy, clairvoyance, etc.), unusual perceptual experiences, odd thinking and speech, paranoid ideation, inappropriate or constricted affect, eccentric behaviour or appearance, lack of close friends, and/or excessive social anxiety that does not diminish with familiarity. These characteristics can be found in the general population (Badcock & Dragović, 2006) and also in relatives of patients with schizophrenia (Gutiérrez Maldonado et al., 2006), suggesting that schizotypy could be originated due to both genetic and environmental factors, as well as to an interaction or combination between them (Obiols & Vicens-Vilanova, 2003). This idea was defended by Meehl (1962, 1989) in his schizotaxia model, which suggests a genetic predisposition to schizophrenia due to the existence of a dominant gene able to trigger an integrative shortcoming in the central nervous system. This, together with independent genes that enhance anxiety and hypohedonia, as well as other developmental factors and stressors, allow the complete development of schizophrenia.

Patients with schizophrenia have shown a worse recognition of emotional facial expressions than the general population (Chan et al., 2010; Kohler, et al., 2010) both in labelling and matching tasks (Bediou et al., 2005). From a neurobiological perspective, these patients have abnormalities in the functionality of almost every brain structure related to emotional and facial processing (Gur et al., 2007; Habel et al., 2010; Hooker et al., 2011; Seiferth et al., 2009; Williams, 2008), showing less activation in bilateral amygdala, parahippocampal gyrus, fusiform gyrus, right superior frontal gyrus, and lentiform nucleus in comparison with healthy people (Li et al., 2010). These difficulties become more noticeable when these patients have to recognise facial expressions of negative emotions (fear, disgust, sadness, and anger) and are related to the negative symptoms of schizophrenia (such as anhedonia and non-paranoid symptoms; for a review, see Mandal, Pandey, & Prasad, 1998). A similar effect has been observed in people with schizotypal traits (Williams et al., 2007). The higher the schizotypy negative symptoms score, the higher the deficit recognising facial expressions of negative emotions. Most evidence suggests a relationship between schizotypy and a deficit related to the recognition of emotional facial expressions (Abbott & Green, 2013; Brown & Cohen, 2010; Morrison et al., 2013; Poreh et al., 1994; Williams et al., 2007), although there are some inconsistent data (Jahshan & Sergi, 2007; Toomey & Schuldberg, 1995; Toomey et al., 1999).

The recognition of emotional facial expressions plays an important role in our daily life. It provides important information for almost all social

interactions and for some basic and essential functions such as, for example, parenting, which is quite difficult for parents with schizophrenia because they are more likely to misinterpret infants' cues (Miller, 1997). For this reason, we consider that it is necessary to develop tools that may improve this ability. The differential outcomes procedure (DOP) could be one of such tools. The DOP consists in associating a specific outcome with each stimulus-response sequence that has to be learned or with each stimulus to be remembered. In comparison with the non-differential outcomes procedure (NOP), the most commonly used, consisting in the random presentation of the outcomes following correct responses, previous studies have demonstrated that the DOP enables a faster and more accurate learning (Estévez et al., 2001; Maki et al., 1995; Miller et al., 2002; Mok & Overmier, 2007), a higher long-term retention of the learned information (Martínez et al., 2009; Molina et al., 2015; Plaza et al., 2018), and a better delayed visuospatial recognition memory (Esteban et al., 2014; Esteban et al., 2015; Hochhalter et al., 2000; López-Crespo et al., 2009; Plaza et al., 2011; Plaza et al., 2012) in populations with and without cognitive impairments. A recent study (Plaza et al., 2013) involves recognising the facial identity of faces changing their emotional facial expression from neutral to sadness or happiness. When using the DOP, participants showed better identity recognition than when the NOP was applied. However, there is no research exploring whether this procedure might improve the recognition of emotional information.

In our research, we aim to further explore whether people scoring high in schizotypy may differ in their ability to recognise emotional facial expressions from those scoring low in schizotypy. In addition, we use for the first time, as far as we know, the differential outcomes training to check whether it may improve the recognition of emotional facial expressions, especially in those participants scoring high in schizotypy. Based on the aforementioned studies, we expect to find a worse recognition of negative emotional facial expressions (fear, disgust, anger and/or sadness) in the former group than in the latter group. We also predict a better recognition of emotional facial expressions when the DOP is used and that this effect would be more pronounced for the group of participants scoring high in schizotypy.

METHOD

Participants. Two hundred and ninety-eight volunteers (undergraduate students, 89 men and 209 women) from the University of Almería (Spain), ranging in age from 18 to 30 years (Mmen = 22, SDmen = 4.6; Mwomen = 20.8, SDwomen = 5.07), with normal or corrected-to-normal vision, were

assessed using the Oviedo Schizotypy Assessment Questionnaire-Abbreviated (ESQUIZO-Q-A; Fonseca-Pedrero et al., 2012). Depending on their score, they were assigned to one of the two experimental groups: high schizotypy (HS) or low schizotypy (LS). Following the percentiles exposed by the authors in their validation of the questionnaire (Fonseca-Pedrero et al., 2010), participants who scored above the 75th percentile in two or more factors were assigned to the HS group, while participants who scored below the 50th percentile in at least two factors, and below percentile 60th in the other factor were assigned to the LS group. This criterion has been used in a previous article and it allows to select participants with high schizotypy in more than one dimension, discarding those with high unidimensional schizotypy (García-Montes et al., 2014).

This way, forty-one participants who met this criterion were interested in participating in the study, 26 from the HS group (three men and 23 women; M age = 20 years) and the remaining 15 from the LS group (three men and 12 women; M age = 22.9 years). All participants gave written informed consent before data collection began and received two course credits for their participation. The study was approved by the University of Almería Human Research Ethics Committee and was conducted in accordance with the Declaration of Helsinki.

Instruments. The ESQUIZO-Q-A (Fonseca-Pedrero et al., 2012) is the abbreviated form of the ESQUIZO-Q (Fonseca-Pedrero et al., 2010), a self-reported questionnaire, which was developed to measure schizotypal traits in teenagers, although it has been also applied to university students (García-Montes et al., 2014). This questionnaire is based on the diagnostic criteria presented in the DSM-IV-TR (American Psychiatric Association, 2000) and on Meehl's model of schizotaxia (Meehl, 1962, 1989). It is comprised of a total of 23 statements that are answered using a 5-point Likert scale (from 1 totally disagree to 5 totally agree) grouped into three subscales: Reality Distortion (RD), Anhedonia (AN), and Interpersonal Disorganization (ID). RD subscale includes 6 items referring to magical thinking, unusual perceptual experiences, and paranoid ideation; its score ranges from 6 to 30 (α = .70). AN subscale comprises 7 items regarding physical and social anhedonia; its score ranges from 7 to 35 (α = .65). Finally, ID subscale includes 10 items referring to odd thinking, speech, and behaviour, ideas of reference, lack of close friends, and excessive social anxiety; its score ranges from 10 to 50 (α = .78).

A task involving the recognition of emotional facial expressions was designed using E-prime 2.0 (Psychology Software Tools, 2007). The stimuli were colour pictures of 20 European people (10 men and 10 women) included in the NimStim Set of Facial Expressions database (Tottenham et al., 2009;

http:/www.macbrain.org/resources.htm). Seven pictures from each of these people were selected, each showing one of the following emotional facial expressions: neutral, happiness, sadness, fear, anger, disgust, and surprise. Pictures were displayed on 15-inches VGA monitors of IBM-compatible computers over a white background. During the experiment, participants were at a distance of 60 cm from the screen and the size of the stimuli was 115 x 140 pixels. After the correct responses, participants received, as an outcome, a picture of one of the following reinforcers: an electric massager, a book, a pen-drive, a keychain, a mug, a table game, and a ten-euro bill. They were presented individually on the centre of the screen along with the phrase Great! You may win a (the name of the reinforcer). Once the study was completed, these reinforcers were raffled off among the participants.

Procedure. In the initial assessment phase, the ESQUIZO-Q-A (Fonseca-Pedrero et al., 2012) questionnaire was applied in a classroom to 298 undergraduate students distributed in groups of 30 participants (the time required to complete the questionnaire was approximately 10 minutes). Trained staff administered the questionnaire and informed to all participants that their answers would be handled only for scientific purposes.

In the experimental phase, two 30-minutes sessions separated by one week were scheduled. Participants were tested individually in a quiet room. We designed two versions of the emotional facial recognition task by using two different sets of 10 faces (five men and five women per set), which were counterbalanced between the sessions. In the first session, participants were randomly assigned to one of the two possible outcomes conditions (differential outcomes —DOP—, or non-differential outcomes —NOP—). In the next session, they had to perform the task on the opposite outcomes condition with the alternative set of faces. This way, 22 participants (14 HS, 8 LS) were first assigned to the NOP condition and 19 participants (12 HS, 7 LS) to the DOP condition.

When the DOP was applied, each sample stimulus (each emotional facial expression) was associated with a specific reinforcer prize picture as the outcome, and the correct responses to that stimulus were always followed by that outcome. For example, the faces of happiness were always associated with the picture of the electric massager under the DOP condition. By contrast, under the NOP condition, correct responses were randomly followed by any of the possible outcomes.

At the beginning of each experimental session, participants were verbally instructed about the task. Furthermore, the instructions appeared also written on the computer screen. They were told that they were about to see

emotional facial expressions and that they had to recognise them responding as accurately and as quickly as possible. This facial emotional recognition task consisted of 140 trials grouped into two blocks of 70 trials each. For each block, randomized among the participants, they performed one of two different tasks: a matching or a labelling task. Each trial started with a fixation point (+) for 500ms (see Figure 1). After a blank screen lasting 250ms, the sample stimulus (a face showing an emotional expression) appeared for 1000ms. Then, participants saw either seven faces of different people with just one showing the same emotional facial expression as the sample stimulus (matching task), or the name of the seven possible emotions that could be expressed by the face (labelling task). A number next to each stimulus (from 1 to 7) represented the key assigned to respond. The stimuli were on the screen until a response was made or 10 seconds elapsed (whichever occurred first). Following a correct response, a picture of a reinforcer along with the phrase: Great! You may win a (the name of that reinforcer)! appeared for 2500ms. If the response was incorrect, a blank screen appeared for the same time as the outcome presentation. Afterwards, the next trial started.

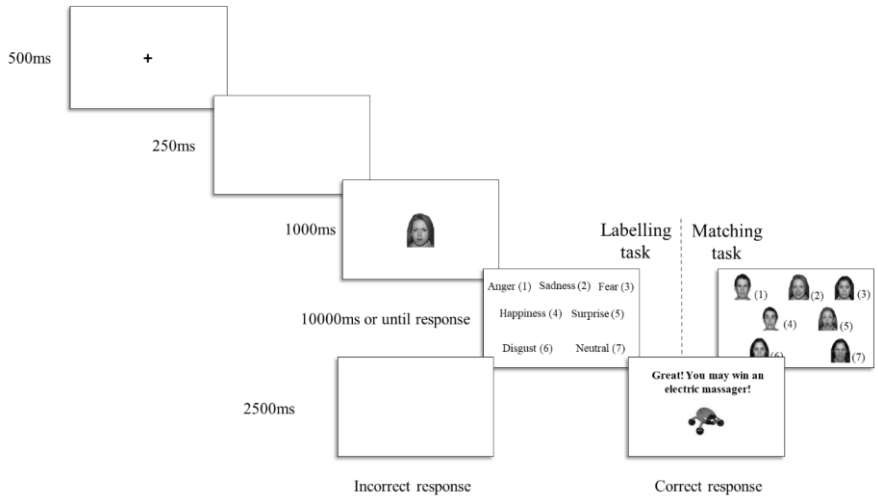

Fig. 1. Stimuli sequence (from left to right) used in the two blocks (labelling and matching tasks) of the facial emotion recognition task. Due to the limitation of the publication of faces indicated by the authors of the database, in this example some actors appear more than one time on the same trial. In the original task, a trial never included the same actor's face more than once.

Data analysis. Scores of each ESQUIZO-Q-A subscale (Fonseca-Pedrero et al., 2012) were analysed using a student t-test as a function of group (HS vs. LS) and sex (Male vs. Female).

Normality and homoscedasticity of the experimental data were tested using Kolmogorov–Smirnov's and Levene's tests respectively. Results indicated that the assumptions to perform ANOVAs were satisfied neither by accuracy data (mean of the percentages of correct responses) nor by latency data (mean of the medians of the correct reaction times —RTs—). Normality could not be assumed because almost all measurements in Kolmogorov-Smirnov's test were below the significance level ($p < .05$). Besides, Levene's test revealed variance heterogeneity between groups in some measurements. Thus, we decided to use a more robust approach here, adopting Welch-type statistics (Welch, 1938, 1951) for the analysis of variance and post-hoc comparisons, which do not pool across heterogeneous sources of variability and estimate the error degrees of freedom from the sample data (Keselman et al., 2003). Emotion (neutral, happiness, sadness, fear, anger, disgust, and surprise), task (matching vs. labelling), and session (First vs. Second) were taken as within-subject factors, while schizotypy group (HS vs. LS) and outcomes group (First DOP, then NOP vs. First NOP, then DOP) were considered as between-subject factors. Trimmed means and Winsorized variances were used to carry out the analyses. These estimators have been confirmed to overcome the biasing effects of non-normality (Lix & Keselman, 1998; Wilcox, 2012). In order to discard the least amount of data, we decided to use a symmetric trimming of 10% since it may be the best choice for dealing with non-normal data (Stigler, 1977). All these analyses were performed through the "welchADF" (Villacorta, 2017) "R" (R Core Team, 2018) package. In order to facilitate the reading of the article, only significant results will be commented.

Since previous studies have shown that the pattern of results obtained through the application of the DOP is similar for men and women (Esteban et al., 2015; Estévez et al., 2001) and due to the small number of men in each group in our sample, Sex was not included as a between-subject factor in the statistical analyses. Due to technical problems, RTs from one of our participants could not be obtained.

RESULTS

Assessment phase. Student t-tests indicated that there were no differences among the participants in the different subscales of the ESQUIZO-Q-A (Fonseca-Pedrero et al., 2012) regarding sex, $t_{RD}(39) = .872$, $t_{AN}(39) = -.613$, $t_{ID}(39) = .072$, all *ps* > .05. Analyses of the scores obtained

by our participants in each subscale of the questionnaire revealed higher values for the HS group compared to the LS group in the RD, $t(33.6) = 5.412$, $p < .001$, the AN, $t(38.5) = 4.321$, $p = .001$, and the ID, $t(39) = 8.526$, $p < .001$, subscales. See Table 1 for more details.

Table 1
Mean and standard deviations of the scores of each subscale of the ESQUIZO-Q-A obtained by participants as a function of sex and group.

	Sex				Group			
	Male (n=6)		Female (n=35)		HS (n=26)		LS (n=15)	
Subscale	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
RD	12.7	4.1	11.1	4.2	13.1	4.2	8.2	1.4
AN	11.2	2.6	11.9	2.8	12.8	2.8	10	1.4
ID	27.5	10.1	27.3	7.3	31.9	5.0	19.3	3.7

Note. HS, High schizotypy group; LS, Low schizotypy group; RD, Reality Distortion; AN, Anhedonia; ID, Interpersonal Disorganization.

Experimental phase: Accuracy. Table 2 shows the mean percentage of correct responses, as well as the winsorized standard deviations obtained by participants (after applying 10% trimming) in the experiment as a function of emotion, task, session, schizotypy group, and outcomes group. The Welch-James statistic revealed, on the omnibus contrasts, significant main effects of task, $T_{WJ}(1, 16.2) = 28.669$, $p < .001$, session, $T_{WJ}(1, 28.6) = 4.391$, $p = .045$, and emotion, $T_{WJ}(6, 19.4) = 73.844$, $p < .001$, which were modulated by the significant Outcomes group × Session, $T_{WJ}(1, 28.6) = 4.376$, $p = .045$, and Task × Emotion, $T_{WJ}(6, 18.5) = 8.864$, $p < .001$, interactions. This latter interaction was also modulated for a higher-order interaction of four factors, the Task × Emotion × Outcomes group × Schizotypy group, $T_{WJ}(6, 18.5) = 2.982$, $p = .032$

Table 2

Mean percentages of the correct responses after 10% trimming is applied (and winsorized standard deviations) obtained by participants as a function of schizotypy group, task, outcomes group, session and emotion.

	High schizotypy								Low schizotypy							
	Labelling				Matching				Labelling				Matching			
	DOP-NOP		NOP-DOP		DOP-NOP		NOP-DOP		DOP-NOP		NOP-DOP		DOP-NOP		NOP-DOP	
Emotion	SES 1	SES 2	SES 1	SES 2	SES 1	SES 2	SES 1	SES 2	SES 1	SES 2	SES 1	SES 2	SES 1	SES 2	SES 1	SES 2
Disgust	89.0 (10.0)	86.0 (9.4)	90.0 (9.9)	90.0 (9.1)	83.0 (14.6)	86.0 (12.4)	73.3 (21.6)	79.2 (10.2)	90.0 (11.5)	92.9 (6.0)	81.3 (9.8)	93.8 (5.8)	82.9 (11.1)	72.9 (7.8)	73.8 (14.6)	88.8 (9.8)
Anger	92.0 (9.4)	91.0 (3.5)	89.2 (9.5)	88.3 (8.9)	86.0 (7.5)	91.0 (9.0)	77.5 (13.1)	85.8 (9.5)	88.6 (9.0)	81.1 (10.1)	92.5 (6.5)	88.8 (2.5)	80.0 (8.2)	80.0 (9.9)	86.3 (11.9)	88.8 (5.0)
Happiness	100.0 (0.0)	100.0 (0.0)	97.5 (6.4)	99.2 (2.5)	98.0 (4.5)	96.0 (5.1)	96.7 (5.0)	99.2 (2.5)	97.1 (3.0)	97.1 (4.9)	100.0 (0.0)	98.8 (1.1)	97.1 (4.9)	98.6 (1.5)	98.8 (1.1)	100.0 (0.0)
Fear	71.0 (19.0)	65.0 (20.0)	61.7 (20.6)	67.5 (23.4)	72.0 (15.1)	74.0 (17.3)	64.2 (14.3)	70.0 (18.6)	65.7 (25.9)	71.4 (22.3)	62.5 (18.0)	77.5 (17.0)	57.1 (11.1)	62.9 (14.7)	56.3 (14.5)	62.5 (12.1)
Neutral	90.0 (13.8)	97.0 (4.9)	92.5 (8.0)	97.5 (4.7)	88.8 (14.3)	88.8 (8.3)	80.8 (12.3)	94.2 (6.6)	100.0 (0.0)	92.9 (6.0)	90.0 (9.0)	98.8 (1.1)	88.6 (9.1)	82.9 (14.7)	81.3 (10.6)	90.0 (8.0)
Surprise	94.0 (5.1)	90.0 (8.5)	99.2 (2.5)	95.8 (8.5)	87.0 (8.7)	89.0 (10.0)	87.5 (10.7)	90.8 (8.3)	85.7 (10.6)	94.3 (5.3)	88.8 (12.5)	90.0 (10.4)	81.4 (10.6)	88.6 (7.5)	81.3 (10.6)	88.8 (12.5)
Sadness	66.0 (17.8)	68.0 (16.4)	64.2 (17.6)	65.8 (20.3)	68.0 (12.9)	66.0 (12.4)	60.0 (15.7)	70.0 (11.6)	67.1 (17.5)	64.3 (14.4)	71.3 (17.0)	78.8 (19.6)	62.9 (11.7)	55.7 (10.9)	63.8 (10.7)	81.3 (15.3)
All	88.2 (14.0)	87.6 (15.6)	87.4 (15.2)	89.4 (13.8)	84.4 (13.6)	85.4 (13.7)	78.1 (17.1)	85.5 (13.8)	88.0 (15.1)	88.5 (13.7)	86.3 (15.0)	82.8 (10.3)	79.5 (16.8)	78.5 (17.4)	78.9 (17.5)	88.3 (12.4)

Note. DOP, Differential outcomes procedure; NOP, Non-differential outcomes procedure; S1, Session 1; S2, Session 2; DOP-NOP, Group starting in the DOP condition; NOP-DOP, Group starting in the NOP condition.

Regarding the Outcomes group × Session interaction, the analyses revealed that only participants who started with the NOP condition had a better performance in the second session with the DOP condition, $t_{WJ}(17.1) = 9.98$, $p = .005$, $\hat{\delta}_R = 10.65$; $M_{Ses1} = 82.8\%$, $M_{Ses2} = 88.7\%$, while participants who started with the DOP condition showed the same performance in the second session with the NOP condition, $t_{WJ}(13.3) = .00$, $p = .998$, $\hat{\delta}_R = .01$; $M_{Ses1} = 85.7\%$, $M_{Ses2} = 85.7\%$ (see Figure 2).

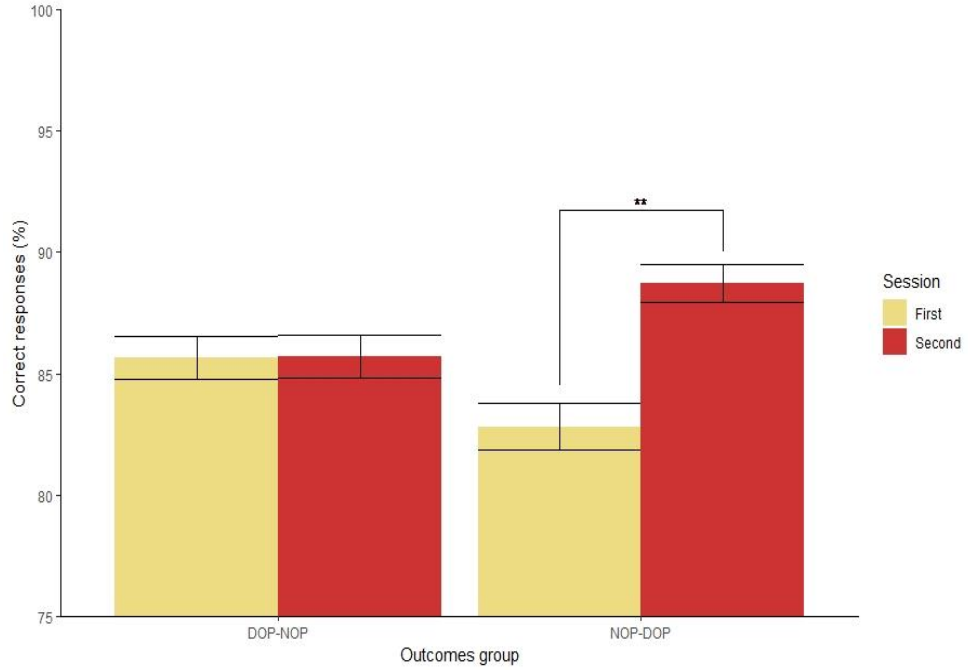

Fig. 2. Trimmed means (10%) of the correct responses' percentage of our participants as a function of outcomes group and session. Error bars represent the standard error of the trimmed means. The asterisks (**) indicate a significant difference ($p < .01$).

For the analyses of the Task × Emotion × Outcomes group × Schizotypy group interaction, we isolated every level of every variable looking for a three-way interaction. After that, we looked for a two-way interaction that could better explain the effect.

When we isolated the schizotypy groups and the different tasks, no three-way interaction was revealed. After isolating every emotion, the only one that revealed a significant three-way interaction of Task × Outcomes group × Schizotypy group was disgust, $T_{WJ}(1, 26.6) = 1.061$, $p = .003$. Subsequently, we repeated the process, and the only isolation that resulted in a two-way interaction was that of the HS group, indicating a Task ×

Outcomes group interaction, $T_{WJ}(1, 16.9) = 9.175$, $p = .007$. This latter interaction revealed that disgusted faces were better recognised by participants of the HS group that started with the DOP than those that started with the NOP just in the matching task, $t_{WJ}(16.9) = 6.00$, $p = .026$, $\hat{\delta}_R = .91$; $M_{DOP\text{-}NOP} = 85.0\%$, $M_{NOP\text{-}DOP} = 76.7\%$. In the labelling task, this effect did not take place, $t_{WJ}(20.0) = .81$, $p = .379$, $\hat{\delta}_R = .41$; $M_{DOP\text{-}NOP} = 87.5\%$, $M_{NOP\text{-}DOP} = 90.0\%$.

Another significant three-way interaction of Task × Emotion × Schizotypy group took place when we isolated the outcomes group that started with the DOP, $T_{WJ}(6, 9.9) = 6.205$, $p = .006$. Then, we repeated the process, and isolating the emotion disgust a new two-way interaction of Task × Schizotypy group was revealed, $T_{WJ}(1, 11.0) = 11.444$, $p = .006$. This last interaction revealed that disgusted faces were better recognised in the labelling task than in the matching task in the LS group that started in the DOP condition, $t_{WJ}(6.0) = 27.08$, $p = .002$, $\hat{\delta}_R = 1.91$; $M_{Lab} = 92.5\%$, $M_{Match} = 78.3\%$. This effect did not take place in the HS group, $t_{WJ}(9.0) = 3.04$, $p = .115$, $\hat{\delta}_R = .42$; $M_{Lab} = 87.5\%$, $M_{Match} = 85.0\%$.

Experimental phase: Latency. The means of the medians and the winsorized standard deviations of the correct responses RTs obtained by participants (after 10% trimming is applied) in this experiment as a function of emotion, task, session, schizotypy group, and outcomes group are presented in Table 3. The Welch-James statistic revealed, on the omnibus contrasts, significant main effects of task, $T_{WJ}(1, 29.6) = 1198.000$, $p < .001$, session, $T_{WJ}(1, 24.8) = 5.369$, $p = .029$, and emotion, $T_{WJ}(6, 15.9) = 77.800$, $p < .001$, which were modulated by the significant Task × Emotion, $T_{WJ}(6, 19.9) = 14.970$, $p < .001$, and Task × Session × Outcomes group, $T_{WJ}(1, 23.4) = 4.465$, $p = .045$, interaction.

Table 3. Means of the medians of the correct reaction times (in milliseconds) after 10% trimming is applied (and winsorized standard deviations) obtained by participants as a function of schizotypy group, task, outcomes group, session and emotion.

Emotion	High schizotypy								Low schizotypy							
	Labelling				Matching				Labelling				Matching			
	DOP-NOP		NOP-DOP		DOP-NOP		NOP-DOP		DOP-NOP		NOP-DOP		DOP-NOP		NOP-DOP	
	SES 1	SES 2	SES 1	SES 2	SES 1	SES 2	SES 1	SES 2	SES 1	SES 2	SES 1	SES 2	SES 1	SES 2	SES 1	SES 2
Disgust	1302 (339)	1076 (236)	1124 (177)	1275 (412)	2463 (504)	2834 (573)	2675 (576)	2700 (263)	1044 (389)	1307 (450)	1480 (473)	1405 (313)	2577 (555)	2563 (279)	2787 (818)	2810 (429)
Anger	1609 (489)	1487 (448)	1420 (679)	1385 (387)	2963 (288)	2720 (763)	2936 (697)	2874 (418)	1376 (391)	1137 (508)	1763 (276)	1496 (349)	2583 (555)	2542 (484)	3286 (480)	2653 (206)
Happiness	978 (381)	1169 (334)	1041 (462)	762 (340)	2373 (371)	2263 (351)	2255 (319)	2142 (333)	949 (479)	724 (327)	1014 (434)	980 (172)	2163 (322)	2188 (356)	2343 (328)	2294 (170)
Fear	2126 (653)	1814 (410)	1695 (621)	1728 (417)	3041 (551)	3170 (525)	3080 (861)	2858 (479)	1798 (624)	1667 (459)	2012 (783)	1925 (711)	2633 (684)	3056 (558)	3774 (861)	3099 (653)
Neutral	1442 (241)	1091 (368)	876 (283)	695 (379)	3187 (413)	2966 (333)	3337 (682)	2856 (460)	924 (361)	773 (445)	1216 (383)	939 (418)	2857 (258)	2735 (614)	3161 (531)	2781 (332)
Surprise	1572 (366)	1413 (232)	1244 (263)	1441 (389)	2776 (585)	2672 (585)	2815 (971)	2505 (533)	1314 (237)	1331 (409)	1501 (310)	1696 (628)	2693 (754)	2496 (1039)	3038 (445)	2582 (343)
Sadness	2094 (798)	1754 (439)	1558 (819)	1728 (426)	3647 (807)	3322 (691)	3501 (662)	3489 (621)	1732 (361)	1472 (407)	1958 (489)	1824 (152)	3179 (539)	3438 (452)	3790 (386)	3487 (518)
All	1549 (549)	1390 (417)	1232 (502)	1284 (522)	2900 (544)	2833 (606)	2899 (764)	2768 (553)	1295 (474)	1162 (486)	1520 (481)	1402 (382)	2609 (618)	2660 (648)	3143 (644)	2763 (484)

Note. DOP, Differential outcomes procedure; NOP, Non-differential outcomes procedure; S1, Session 1; S2, Session 2; DOP-NOP, Group starting in the DOP condition; NOP-DOP, Group starting in the NOP condition.

The Task × Emotion interaction revealed a main effect of emotion in both labelling, $T_{WJ}(6, 18.7) = 39.366$, $p < .001$, and matching tasks $T_{WJ}(6, 18.2) = 59.490$, $p < .001$. Participants were always faster in the labelling task than in the matching task (all *ps* < .001), however, they showed different RTs as a function of emotion in each task. In the labelling task, the responses to fearful faces and sad faces were similar ($p = .78$), and slower than the other five emotional facial expressions ($M_{Fear} = 1759$, $M_{Sadness} = 1732$ms; all *p*s < .05). They were followed by angry, and surprised faces ($M_{Anger} = 1441$ms, and $M_{Surprise} = 1390$ms; there were no significant differences between them, *ps* > .05 and significant differences with all the other emotions, *ps* < .05), and next by disgust ($M_{Disgust} = 1210$ms, all *ps* < .05). The fastest responses were elicited by happy and neutral faces ($M_{Neutral} = 957$ms, $M_{Happiness} = 937$ms; there were no significant differences between them, *p*s > .05 and significant differences with all the other emotions, *ps* < .05). By contrast, in the matching task, the slowest responses were observed for the sad faces (MSadness = 3476ms; *ps* < .001 when comparing with the other six emotions), followed by neutral, fearful, and angry faces ($M_{Neutral} = 2995$ms, $M_{Fear} = 2988$ms and $M_{Anger} = 2801$ms; there were no significant differences between them, *ps* > .05 and significant differences with all the other emotions, *ps* < .05), and then disgusted and surprised faces ($M_{Disgust} = 2642$ms, and $M_{Surprise} = 2628$ms; there were no significant differences between them, $p > .05$ and significant differences with all the other emotions, *ps* < .05, except anger). Again, the recognition of happy faces elicited the fastest responses ($M_{Happiness} = 2235$ms; *ps* < .01 when comparing with the rest of the emotions).

Interestingly, regarding the Task × Session × Outcomes group interaction, the isolation of the outcomes group revealed that only those who started in the NOP condition expressed a Task × Session interaction, $T_{WJ}(1, 15.8) = 6.648$, $p = .020$. This interaction showed that, in the matching task, this group was significantly faster in the second session, when they did the task in the DOP condition, $t_{WJ}(16.2) = 9.94$, $p = .006$, $\hat{\delta}_R = 5.15$; $M_{Ses1} = 2966$ms, $M_{Ses2} = 2767$ms. However, in the labelling task, they showed the same reaction time, $t_{WJ}(9.5) = .34$, $p = .573$, $\hat{\delta}_R = 1.01$; $M_{Ses1} = 1315$ms, $M_{Ses2} = 1321$ms (see Figure 3).

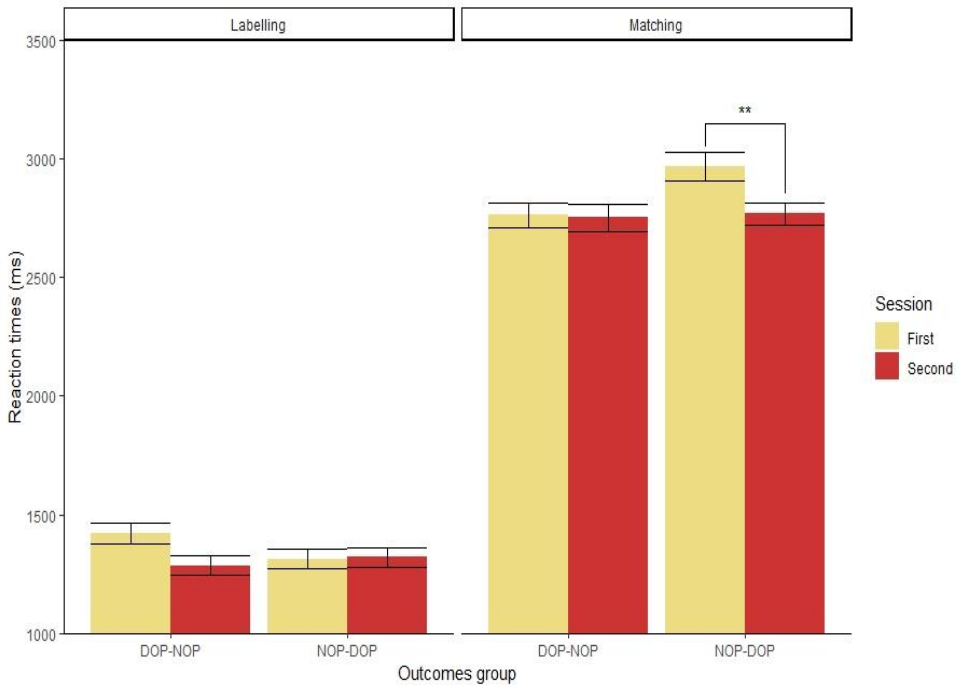

Fig. 3. Trimmed means (10%) of the medians of the correct reaction times of our participants as a function of outcomes group, session and task. Error bars represent the standard error of the trimmed means. The asterisks (**) indicate a significant difference ($p < .01$).

DISCUSSION

The purposes of the present study were (i) to explore possible differences between those people scoring high and low in schizotypy when they had to recognise different emotional facial expressions and (ii) to investigate, for the first time, whether the DOP can be useful to improve this ability, especially in those participants scoring high in schizotypy, who are supposed to present a deficit related to emotional facial processing (Abbott & Green, 2013; Brown & Cohen, 2010; Morrison et al., 2013; Poreh et al., 1994; Williams et al., 2007).

Regarding the first aim, we did not find any differences in the accuracy of the participants depending on their schizotypal personality traits. As previously noted, there is not a clear consensus in the literature about this issue. While some studies report significant impairments in this ability in people with schizotypal personality traits (Abbott & Green, 2013; Brown & Cohen, 2010; Morrison et al., 2013; Poreh et al., 1994; Williams et al., 2007),

other studies did not detect this effect (Jahshan & Sergi, 2007; Toomey & Schuldberg, 1995; Toomey et al., 1999). Due to this discrepancy of findings, more studies are needed to further explore this issue. However, with respect to the second purpose, we found that the DOP improve the performance of all our participants, and that it may be even more beneficial for the HS group in some situations, concretely, when participants had to recognise disgusted faces.

On the one hand, in the matching task, disgusted faces were better recognised by participants of the HS group that started in the DOP condition than by participants of the HS group that started in the NOP condition. On the other hand, participants of the HS group that started in the DOP condition had a similar performance in both labelling and matching tasks when they have to recognise disgusted faces, which suggests that the typical higher difficulty of the matching task we observed in this study was some way ameliorated by the application of this procedure. None of these effects took place in the LS group. Williams et al. (2007) highlights that negative emotions are especially difficult to recognise by people presenting schizotypal personality traits, which could explain why the beneficial effect of the DOP could be higher in the HS group when they have to recognise disgusted faces, but it would also be expectable to find this effect in emotions that apparently are even harder to-be-recognised, such as fear and sadness. Notwithstanding, it is important to be cautious about these results since we are aware of the small sample size of our groups, which may not be adequate in order to interpret a four-way interaction. Future studies may explore this issue.

Remarkably, we have demonstrated for the first time the effectiveness of the DOP as a useful tool to improve the recognition of emotional facial expressions in the general population, since this effect was present in all our participants. Regarding accuracy, this becomes evident exploring the Outcomes group × Session interaction found when accuracy data was analysed. It is important to note that only participants that started in the NOP condition had a significant improvement in their performance in the second session. Given that participants starting in the DOP condition have a similar performance in the second session, we assume that that improvement was due to the DOP, and not to a learning effect caused by session. In previous studies, this effect of session has not been found, probably because the trained stimuli were not the same in both sessions (e.g., Estévez et al., 2003; Plaza et al., 2012). By contrast, in the present study, even though the identity of the recognised models differed between sessions, the emotions to-be-recognised remained the same, so it might be that the beneficial effect of the DOP lasted

until the next week for the group starting in this condition when they did the second session under the NOP condition. This finding appears to be in agreement with previous results indicating higher long-term retention of the information trained under the DOP (v.g., Carmona et al., 2019), and add the novel result that the long-term benefit of this procedure is also observed even when the outcomes condition is changed.

Participants that started in the NOP condition were also faster in the second session (when the DOP was applied), but only in the matching task. Previous studies (Estévez et al., 2001; Plaza et al., 2011) have pointed out that the difficulty of the task is a key factor when using the DOP since the higher the difficulty, the more beneficial the effect is. Thus, it is expectable that the benefits of associating a specific outcome to each emotional facial expression to-be-recognised were more evident when participants did the matching task, which was more difficult to perform than the labelling one. Besides, as it also happened with accuracy, participants starting in the DOP were equally faster in both sessions, probably due to the reason previously mentioned (that is, to a long-term benefit of the differential outcomes training).

In the same way, we expected to find a better performance (more accurate responses) under the DOP condition when the emotional facial expressions involved were difficult to-be-recognised (negative emotions). However, the DOP improved the overall performance of all our participants, since we did not get any significant interaction involving the outcomes conditions and the emotions. It is worth noting here that both tasks involved only ten trials per emotion in each condition. Even these few trials were enough to capture the differential outcomes effect, so it might be possible that a more extensive training could result in a differential effect for the recognition of negative emotions, which we believe will benefit more positively from the use of this procedure. Further research is needed to address this issue.

One of the limitations of the present study is that all the published research on the emotional facial recognition in schizotypy has employed a tool to assess these personality traits that differ from ours (e.g., the Schizotypal Personality Questionnaire; Raine, 1991). As far as we know, there is only one study using the ESQUIZO-Q-A (Fonseca-Pedrero et al., 2012) with the purpose of exploring spatial memory abilities in young adults scoring high and low in schizotypy (García-Montes et al., 2014). Given that this test was originally developed to measure schizotypal traits in teenagers, it is possible that the cut-offs established on this questionnaire did not work well in our sample. Thus, future studies exploring the potential benefits of the DOP on the emotional facial processing of people scoring high in schizotypy

might consider using a different tool specifically designed to assess young adults (e.g., the Schizotypal Personality Questionnaire; Raine, 1991).

CONCLUSIONS

To conclude, the present study makes an important contribution because it shows, for the first time, that the DOP can improve the recognition of emotional facial expressions both in people scoring high in schizotypy (HS group) and people scoring low in schizotypy (LS group). Besides, it suggests that the DOP might be helpful for people presenting schizotypal personality traits since participants in the HS group starting in the DOP condition especially benefit from this procedure when recognising disgusted faces, although this effect was not observed with other negative emotions. A recent systematic review (Bordon et al., 2017) suggests that improving the emotional facial expression recognition of patients with schizophrenia may lead to a large gain in social functioning for this group. However, since participants of the present research do not belong to the clinical population, it would be necessary to replicate these findings in patients in order to be sure of the usefulness of this procedure to improve these impairments in different populations, so future studies should explore this issue. The fact that the DOP supposes a non-cost procedure easy to implement, make it a perfect candidate in order to be used as a therapeutic tool in any context.

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