ORIGINAL PAPER

Emotional Recognition in Schizophrenia: An Analysis of Response Components in Middle-Aged Adults

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Abstract

Ageing seems to present a bias towards positive stimuli that might be reflected in response times. However, this process is more complex for middle-aged adults, and even more in schizophrenia. In order to examine this issue, an experimental study was carried out in which 48 participants were divided into two groups: an experimental group of 24 participants diagnosed with schizophrenia and a control group of 24 subjects with no disorders. The main objective of the study was to evaluate response time components according to the emotional valence of the stimulus, to test recognition and discrimination in both groups. A battery of 120 images from the International Affective Picture System (IAPS), representing positive, negative and neutral emotional valences, was employed. Response times were evaluated in terms of analysis of variance, as well as its inherent response times components. The results showed slower responses in the group with schizophrenia than in the control one. Moreover, a poorer performance was depicted in the latency components this group. Finally, a differential deficit pattern for emotion between groups was not found.

Keywords Schizophrenia · Response time · Emotional valence · Parameters · Time components

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The interest in clarifying mechanisms that underlie errors or distortions in memory has increased in recent decades. This fact is not surprising, given its multiple implications in different fields, from forensic psychology to our daily life. In this way, several variables have been described, such as psychological and biological factors. The aim of this work is to study the case of recognition in schizophrenia in middle-aged adults. More precisely, a variable related to these, which plays a crucial role in our daily routine, is emotion. A large body of research has studied how emotional valence might have an effect on the encoding distinction between real and imaginary stimuli [23, 27, 33, 40]. On the other hand, it has been reported that the arousal (intensity of activation) has an effect on encoding, and thus this might influence memory through the committing of more errors [21]. However, this issue is more complex for the target population under study.

Firstly, literature has not only pointed out differences in emotion, but also across age groups. According to Gordillo León et al. [9], young adults show a negative bias as a survival strategy and that effect decreases with age towards positive emotional valence. Furthermore, Mather and Carstensen [20] hypothesized that in the active aging process when moving towards older adulthood, positive emotions and their inherent attention load are increased, at the same time as negative affect and negative content are ignored. These results can be explained by the increase in the emotional control capacity with age [17]. In this way, older adults would regulate their emotions better: in other words, they would show improvement in how they can control their attention towards positive or negative stimuli. Furthermore, some studies have pointed out that negative emotions might decline until the age of 60 [4] and positive ones might slowly be incremented slightly [31]. However, the literature seems rather scarce for middle-aged adults and more precisely, when the target population is not a healthy one.

Memory impairment is well documented in schizophrenia, depicting slower reaction times [2, 11], more error rates and greater inter and intra-individual variability in reaction times in comparison with normal controls [36]. However, Herbener [12] pointed out that individuals with schizophrenia apparently tend to show normal emotional response pattern to stimuli, although they show difficulties in linking that information to later decisions. On the other hand, Peters et al. [34] explain that the essence of these results is because patients with schizophrenia might have a liberal attitude in accepting incomplete information as sufficient when judging this information, making them more prone to believe in false memories.

In the present study, a recognition task in terms of emotional valence, is proposed. For this reason, the International Affective Picture System, popularly known as IAPS [16], was selected. This battery presents a high reliability in relation to emotional valence (positive, negative and neutral), arousal (intensity) and dominance (degree of control) stimuli. Moreover, response components were evaluated. In this way, the strategy proposed in this work is to assess differences between group and emotion through response time components. To do so, an analysis of ex-Gaussian fit, that allows us to obtain different components, was proposed. The ex-Gaussian characterization, or in other words, ex-Gaussian fit, can be described through the convolution of three parameters: μ, σ and τ. The interest of this technique lies in some the results found in literature. Here, Leth-Steensen et al. [18] found major differences comparing ADHD children to their age-matched control counterparts in the τ parameter. Following on from this piece of research, some studies have also been focused on the role of the τ parameter, linking it to decision components, such as defective effort control mechanism, attentional lapses [10, 23, 26, 27] and even deficits in prospective memory [1], which is one of the main

complaints in the ageing process. One should bear in mind that he interpretation of this parameter is a subject of much discussion in the literature (see, [38]). However, this strategy is of interest to deepen in the study of emotional valence effect, not only thought the reaction times per se, it also, thought its inherent components.

The main and general aim is to examine differences between the recognition emotional targets versus distracting ones, allowing one to shed light on the nature of emotional encoding and the process of discarding new emotional information in a middle-aged group. Therefore, it is hypothesized that participants with schizophrenia might show a poorer performance than controls in terms of response times and accuracy, and this pattern might be affected by the emotional valence. On the other hand, and as mentioned before, RT are expected to be slower in patients with schizophrenia though a classical analysis of variance. In this way, a second specific aim is to examine the response components, also expecting further evidence for the first goal. More precisely, a higher value in the different ex-Gaussian parameters (or in other words, response time components), might also indicate a poor performance.

Method

Participants

A sample of 24 patients with schizophrenia, and 24 control participants volunteered to take part in the study. Table 1 depicts the main participant's characteristics. A total of 2 participants in the experiment were replaced due to an error rate of higher than 40%. All participants had normal or corrected to normal vision, were native Spanish speakers (half of the sample from the Valencian and the other half from the Aragonese Community). The sample selected for both groups had a male majority. The control group did not report cognitive impairment or neurological disorders.

Table 1 Sociodemografic information with regard to the schizophrenic and control groups

		Schizophrenia ($n = 24$)	Control (n = 24)
	Age	55.18 (SD = 7.20)	56.20 (SD = 4.61)
	Gender (% men)	58.33%	62.5%
Academic level	No high school diploma	1 (4,16%)	0 (0%)
	High school diploma	15 (62.5%)	0 (0%)
	A levels/Further Education	7 (29.17%)	4 (16.67%)
	Universitary studies	1 (4.16%)	20 (83.33%)
Type*	Paranoid schizophrenia	17 (70.83%)	
	Simple schizophrenia	1 (4.16%)	
	Residual schizophrenia	3 (12.5%)	
	Undifferentiated schizophrenia	3 (12.5%)	

*Most patients were diagnosed according to the DSM-IV classification employed in the health care center, except for one subject who was diagnosed according to the ICD-10 classification with simple schizophrenia. The schizophrenic group needed to take different neuroleptics (from 1 to 3), as well as other medications. More precisely, the antipsychotics and other relevant medications employed were: Ziprasidone, Paliperidone, Zuclopenthixol, Clozapine, Sinogan, Etumina, Trazodone, Zeldox, Risperidone, Clorazepate, Olanzapine, Invega, Notamid, Aripiprazole, Abilify, Haloperidol, Fluphenazine, Modecate, Deprax, Rivotril, Quetiapina, Leponex, Xeplion and Decapine. Moreover, four patients also took Clonazepam, Lorazepam and Zolpidem

The exclusion criteria were the presence of comorbidity with other disorders, the inability to complete the experiment, the presence of a clear cognitive deficit, and a score equal to or less than 23 points on the Mini-Test Cognitive (MMSE) by Folstein adapted by Lobo et al. [19]. All the patients with schizophrenia were medicated with antipsychotics (and four of them with antidepressants). As each patient followed a different treatment, this variable was not included as covariant in the data analysis. All of them had a high number of admissions. The average time elapsed from the first hospitalization was 19.52 years (SD = 10.89). The sample was obtained from the *Unidad de Larga Estancia* (Long Stay Unit) and the *Unidad de Media Estancia* (Medium Stay Unit). For the first subgroup, the average time in that unit was 9.42 years (SD = 8.87), while for the second one it was 8.30 years (SD = 7.24).

Materials

The stimuli used were a selection of photographs from the International Affective Picture System (IAPS, [5, 16]) in the Spanish adaptation of Moltó et al. [22]. We selected a total of 120 photographs divided into three sets of 40 photographs based on their scores on valence (positive, negative or neutral). For the purpose of the recognition task, from the 120 images selected, 60 were selected as the target images and 60 as the distracting ones, keeping the proportions of the three sets of emotional valences. In other words, in each set, 20 were neutral images, 20 were negative and 20 were positive (see Table 2).

For the distracting task between blocks of presentation and recognition, participants had to carry out an attentional test, which was chosen in order to create a distraction from the first phase of the experiment. This was the perception of differences test (CARAS-R, [39]). Although this test is indicated for ages 6 to 18 years, it is suitable for people with schizophrenia who might suffer some attentional deficits, as the load of demand and the difficulty is lower.

Procedure

Participants were tested in a quiet room, one by one. The presentation of stimuli and recording of response times were controlled by a Windows operating system through the DMDX software [7]. The experiment consisted of two phases. In the first phase, the 60 target stimuli were presented randomly (20 stimuli for each of the three valence categories) with short exposures of 2 s each. After this first phase, a distracting task was presented. It consisted in identifying a specific face from a group of three faces. The total duration was 3 min. In the second phase, the 60 target stimuli plus the 60 distracting stimuli were presented randomly to

Table 2 Valence and arousal mean for the selected images in the different sets (standard deviation or SD in parenthesis chosen from Moret-Tatay et al. experiment, [27])

		Neutral	Negative	Positive
Target	Valence	5 (0.45)	2.82 (0.75)	7.2 (0.6)
	Arousal	5 (0.46)	6.1 (0.77)	4.8 (1.2)
Distracting	Valence	5.05 (0.58)	2.82 (0.65)	7.2 (0.5)
	Arousal	4 (0.82)	5.9 (0.91)	5.1 (1.3)
Total	Valence	5.03 (0.51)	2.82 (0.69)	7.2 (0.54)
	Arousal	4 (0.66)	6 (0.84)	5 (1.2)

the participants. Each image was presented until the participant gave a response or 2000 ms had passed. The participants were instructed to press a button (labelled" Yes") to indicate whether the stimulus was a target stimulus, and press another button (labelled" No") if the stimulus was a distracting stimulus (did not appear in the first phase). The participants were also instructed to respond as quickly as possible while maintaining a reasonable level of accuracy. The session lasted approximately 40 min.

Design and Analysis

Two different analyses were carried out. First an Analysis of variance (ANOVA) and, secondly, an ex-Gaussian fit to obtain response time components. Regarding the ANOVA, the response times less than 250 ms and over 2000 ms were excluded (less than the 2% of the data set) as well as error trials. The emotional Valence (neutral, negative and positive) was manipulated as within group variable.

As mentioned before, the ex-Gaussian distribution fit was employed to examine reaction times components, obtaining three specific parameters μ, σ and τ, which also can be combined as follows: $M_{ean} = \mu + \tau$ and its variance is $S^2 = \sigma^2 + \tau^2$. These parameters have been examined as the described combination above but it also in an isolated way. More precisely, this strategy allows us to easily work with all data in the dataset. In the previous analysis, trimming may result in a biased statistic because of, in terms of signal theory, it is not easy to distinguish noise from signal. The analysis was characterized by a python script [24]. In this way, information on the probability that a random data sample, obtained from the fitted distribution, is calculated. In other words, the distance between the theoretical curve and the empirical data (and its fitted distribution) is evaluated. As in [24, 25] we evaluate the statistical $z = abs(p_1 - p_2)/\sigma$, where p_1 and p_2 are the parameter we want to compare for two different groups and σ is the combined variance (uncertainties, $\sigma^2 = S_{12} + S_{12}$) in the parameters. With this, we can evaluate the p value as the probability that the observed difference in the parameters is less or equal to the expected difference due to statistical fluctuations, assuming that both parameters come from the same population. The p value is then two times the right tail left by a Gaussian distribution with average 0 and variance σ^2.

Ethics

The study was approved by the Ethics Committee of the health care center involved in the study (reference JOM7jom, 17/03/2017). All the participants, or in some cases their legal guardians, filled out an informed consent.

Results

As depicted in Table 2, the general response time pattern in the target condition for both the schizophrenia and control groups was similar for neutral stimuli; however, the group with schizophrenia was much slower in reacting to the stimulus compared to the control group, in particular for the negative stimuli. Moreover, accuracy might indicate the presence of a floor effect. For the first aim, as mentioned before, the ANOVA was performed for those results between 250 ms and 2000 ms, excluding or trimming those outside this range (considering that those outliers would present more noise than signal, in terms of detection theory, see, [32]).

With regard to response latency, the different factors were examined through an ANOVA. First and as expected, significant differences were found between the target and distractor blocks: $F_{(1, 46)} = 46.50$; $MSE = 24{,}232.19$; $p < 0.001$; $\eta^2 = 0.50$. Secondly, the emotional valence also reached the level of statistical significance: $F_{(2,92)} = 7.12$; $MSE = 6458.64$; $p < 0.005$; $\eta^2 = 0.13$. Finally, no interaction between the blocks (target vs. distractor), group, and the emotional valence (neutral, negative and positive) reached statistical significance. Bonferroni pairwise comparisons indicated that global differences in the reaction times where shorter for the neutral than the emotional conditions and these reached the statistical significance (all $p < 0.05$). However, differences between negative and positive emotion did not reach the statistical significance. This analysis was also carried out with each sample, obtaining the same pattern.

On the other hand, an ANOVA on accuracy was carried out. Here, significant differences were found between the target versus distractor blocks: $F_{(1, 46)} = 10.99$; $MSE = 0.053$; $p < 0.005$; $\eta^2 = 0.19$. In terms of emotional valence, this also reached the statistical significance: $F_{(2,92)} = 8.86$; $MSE = 0.006$; $p < 0.01$; $\eta^2 = 0.16$. Finally, a significant interaction was found between emotional valence (neutral, negative and positive) and group (schizophrenia vs control): $F_{(2,92)} = 7.46$; $MSE = 0.046$; $p < 0.005$; $\eta^2 = 0.14$. Bonferroni pairwise comparisons indicated that global differences in the RTs where shorter for the neutral than negative emotion and these reached the statistical significance ($p < 0.05$). Differences between negative and positive, or neutral and positive emotion did not reach the statistical significance in this analysis, and the pattern was similar for both group independently.

Secondly, we proceeded to characterize the reaction times by an ex- Gaussian fit, allowing as to test the rest of specific aims. More precisely, we fitted the ex-Gaussian distribution by the maximum likelihood method and obtained the uncertainties in these values by bootstrapping. Tables 3 depicts the different parameters obtained by the fitting procedure and their p-values. Regarding the mean of each condition per group, as well as their uncertainties. In general terms, the patients with schizophrenia were slower than the control group for all conditions. Moreover, all parameters were higher for the group with schizophrenia than control, indicating a poor performance not applied specifically for an isolated parameter (Table 4).

Table 3 Response time mean (ms), error rate and standard deviation (parenthesis) for different experimental conditions and groups

	Images	Neutral	Negative	Positive
Control	Target	782.38	822.62	857.42
	SD	102.84	115.93	109.51
	Accuracy	88.96%	80.00%	88.96%
	Distracting	933.11	934.84	968.52
	SD	121.82	104.61	121.69
	Accuracy	96.04%	89.79%	96.88%
Schizophrenia	Target	1024.37	1119.77	1037.36
	SD	196.05	227.97	197.66
	Accuracy	69.17%	71.67%	74.17%
	Distracting	1173.87	1204.24	1180.01
	SD	223.28	204.46	217.73
	Accuracy	83.54%	81.04%	79.79%

Table 4 Isolated parameters μ, σ, τ parameters for different experimental conditions and group

			μ parameter	σ parameter	τ parameter	p
Control	Target	Neutral	645.82	70.91	178.42	0.7
		Positive	627.14	51.97	199.67	0.1
		Negative	640.3	64.94	221.9	0.1
		Total	636.59	62.32	201.17	<.00001
	Distracting	Neutral	655.02	73.38	230.71	<.00001
		Positive	690.05	79.63	224.69	0.7
		Negative	703.86	81.75	240.84	<.00001
		Total	681.67	79.78	233.28	<.00001
	TOTAL		656.42	71.6	223.63	<.00001
Schizophrenia	Target	Neutral	741.78	169.05	287.98	0.2
		Positive	703.67	100.33	384.94	0.6
		Negative	710.3	107.4	397.96	0.2
		Total	724.38	136.15	351.85	<.00001
	Distracting	Neutral	799.39	168.58	366.59	0.2
		Positive	868.9	214.02	335.07	0.1
		Negative	862.14	198.1	376.26	<.00001
		Total	838.57	191.72	363.83	0.000
	TOTAL		773.95	164.31	369.39	<.00001

Finally, with regards to the results in the attention distracting task CARAS-R between experimental blocks (presentation and recognition), controls presented a better performance or accuracy than the group with schizophrenia ($M_{ean} = 35.66$, SD = 3.53, vs $M_{ean} = 25.33$, SD = 10.05, respectively): $t_{(46)} = 4.73$; $p < 0.001$; Cohen's d = 0.37. Moreover, the number of omissions ($M_{ean} = 0.70$, SD = 2.95, vs $M_{ean} = 2.95$, SD = 4.46, respectively) was also lower for the control group: $t_{(46)} = 2.43$; $p < 0.001$; Cohen's d = 0.59.

Conclusions and Discussion.

The objective of the present work was to examine the role of emotional valence in patients with schizophrenia in terms of response times and its inherent ex-Gaussian components. To this end, a study of visual recognition of selected images was carried out according to their emotional load (positive, neutral and negative). The study consisted of two phases: a first phase of presentation of stimuli and a second phase of recognition, through the use of images very similar to those of the first phase. Two groups of participants (with diagnosis of schizophrenia and controls) were evaluated through the present procedure. The results obtained could be explained as follows: i) The group with Schizophrenia presented higher latencies and higher parameters, suggesting a poorer performance under all conditions, ii) The negative condition presented higher values for the τ parameter for all groups, therefore, group differential deficit for emotion was not found.

As mentioned before, higher response latency was found for the group with schizophrenia compared to the control group. This result is consistent with the extensive experimental literature where patients with schizophrenia are often usually up to twice as slow as the control subjects [8, 15]. According to recent research, these slower response times are mainly due to the cognitive component rather than to the motor elements [13]. In particular, this is attributed to possible difficulties in decision-making associated with deficits in information processing [14]. This also might be supported by the idea that discarding new emotional information (or rejecting distracting stimuli) showed higher values for the τ parameter or in other words, a poorer performance. On the other hand, a similar pattern was found for emotional conditions, even if the overall amount of responses were slower for the group with schizophrenia.

Contrary to our hypothesis, this supports the idea pointed out by Herbener [12], where individuals with schizophrenia might show normal emotional response pattern to stimuli, but show difficulties in linking that information to later decisions, as depicted in the distracting phase. More precisely, the current results support this review, where no difference to emotional stimuli has been found in comparisons of subjects with schizophrenic and healthy ones. This result might also be applicable to middle-age.

The literature has shown evidence with regard to how cognitive processing speed declines with age. A large body of theories and models regarding this subject has been proposed in cognitive science [35]. Two of the most widespread models are the processing speed theory [37] and the executive theory [42] that state that a general slowing of processing speed is a major contributor to age-related decline. The first one stipulates that speed processing is critical for age, but it is not an exclusive variable. This theory highlights two main statements: relevant cognitive operations are too slow, and this may interfere in the processing of simultaneous information. On the other hand, the executive theory involves higher-order functions of control and coordination of more basic or fundamental cognitive operations which are sensitive to age, assuming a qualitative change with age (in contrast to the quantitative speed difference). In other words, a specific cognitive process is more affected than another one or when a different strategy is applied. The first theory seems to be supported by the patients with schizophrenia, with a delay or higher values in all parameters in comparison with the control group. Finally, the results also seem congruent with more recent theories specific to the population under study, such as the accumulation model of choice (LBA; [3]). Here more cautious decisions are required to carry out a similar task to the one proposed in the present study. Moreover, the target population might also deal with perceptual deficits before being able to make a decision. This could even be more complicated under the influence of medication. Furthermore, and as indicated by Moustafa et al. [30], patients with schizophrenia might adopt a compensatory strategy of favoring accuracy over response times to improve performance.

In turn, both groups had more errors in target stimuli, indicating a higher load of demand [25]. Even if the task was selected from the previous literature from a cross-sectional study comparing young and older participants [27], the results might depict the difficulty of the task. Moreover, the group with schizophrenia present a great impulsivity, as marked by the large number of commissions in the interference task. However, the effects of the antipsychotics used in the treatment of schizophrenia should be considered when interpreting the results. Some studies suggest that commission errors are more susceptible to the effects of antipsychotic medication and that there may be a relationship between the medication and the results of these studies [6].

This work also presents potential limitations. There are remarkably high error rates, which indicate that the task might be difficult to a certain extent for participants, indicating a floor effect. Furthermore, the group with schizophrenia was taking different neuroleptics, as well as other medications. Thus, it was not possible to include this measure as a covariate, and this may be affecting their results. For future research, it would be interesting to develop an easier series of experiments that might also examine the role attentional demands play and its possible interactions with emotional valence, as indicated by several authors [23, 28]. More-over, men are over represented in the selected sample. However, one should bear in mind that men are more often affected, and on average experience more severe symptoms (WHO, [43]). It seems also important to expand the focus of the research towards motivation, in addition to the valence and arousal of the stimulus, since the motivational effects have a considerable impact on memory. Some pieces of research pointed out that evoking feelings of fear, hope or anger are more likely to produce commission errors [41].

Compliance with Ethical Standards

Conflict of Interest Authors declare no conflict of interest.

Informed Consent All participants must give voluntary informed consent to participate in the research (was approved by an ethical committee reference JOM7jom, 17/03/2017).

Ethical Approval The study was approved by the Ethics Committee of the health care center involved in the study (reference JOM7jom, 17/03/2017).

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