Psicothema 2010. Vol. 22, nº 4, pp. 664-668
www.psicothema.com
ISSN 0214 - 9915 CODEN PSOTEG

Attentional network task performance in schizophrenic patients

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Several studies have researched the attentional functioning of schizophrenic patients by means of the Attentional Network Test. The present work reviews these studies and assesses the clinical relevance of their results. Both the reviewed data and our own results suggest that the Attentional Network Test does not provide a clear-cut discrimination of the attentional profile of schizophrenic patients from a clinical point of view. However, after classifying patients according to their psychotic symptoms, it became evident that positive syndrome patients are less efficient at tasks that tap the orientation network.

Ejecución en el test de las redes atencionales en pacientes esquizofrénicos. Varios estudios han investigado el sistema atencional de pacientes esquizofrénicos usando el test de las redes atencionales. En este trabajo se revisan estos estudios y se evalúa la relevancia clínica de sus resultados. Los resultados de la revisión y del presente trabajo sugieren que el test de las redes atencionales no discrimina claramente el perfil atencional de los pacientes esquizofrénicos desde un punto de vista clínico. No obstante, tras subdividir a los pacientes en función de su sintomatología psicótica se evidenció que los pacientes con síndrome positivo mostraron una menor eficiencia en la red de orientación.

The presence of attentional deficits in schizophrenic patients is one of the central characteristics of this pathology (Elvevag & Goldberg, 2000). Recent studies have tried to specify the attentional deficits observed in schizophrenia by means of Posner's theoretical model of attention (Posner & Petersen, 1990) and the ANT task (Fan, McCandlis, Sommer, Raz, & Posner, 2002).

Posner and Petersen (1990) define attention as a modular system that controls information processing by means of three cerebral networks: the vigilance (or alertness) network; the posterior (or orientation) network; and the anterior (or conflict) network. The function of the alertness network is to prepare for sensory stimulus. There is evidence that the alertness network is related to frontal and right parietal regions, as well as to the reticular formation (Sturm & Willmes, 2001). The function of the orientation network is to select sensory stimuli, and its activity is related to the posterior parietal cortex, the pulvinar nucleus of the thalamus and the superior colliculi (Posner & Raichle, 1994). The function of the anterior network is processing task-relevant information. This network is localized in lateral prefrontal and anterior cingulated regions and is intimately associated with executive functions (Posner & Fan, 2005). This model is not without its critics though. For example, Fellows & Farah (2005) showed that patients with bilateral damage to the cingulated area did not exhibit any deficits on executive functioning.

Fecha recepción: 11-11-09 • Fecha aceptación: 28-4-10
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The activity of these three attentional networks can be measured by means of the ANT task (Fan et al., 2002), which provides a measure of the efficiency of the three proposed networks in Posner's model in an efficient an economic way. The ANT is an adequate tool for the study of attention in the schizophrenic spectrum for several reasons: it rests on a firm theoretical base; it allows to evaluate different components of attention (the three networks); and it has been used in diverse clinical conditions (Fernández-Duque & Black, 2006; Posner, 2003; Sobin, Kiley-Brabeck, Daniels, Blundell, Anyane-Yeboa, & Karaiyorgou, 2004).

Several studies have investigated the attentional characteristics of schizophrenic patients by means of the ANT (Gooding, Braun, & Studer, 2006; Nestor, Kubicki, Spencer, Niznikiewic, McCarley, & Shenton, 2007; Wang, Fan, Dong, Wang, Lee, & Posner, 2005). The main conclusions to draw from these studies are that there exist specific deficits in the anterior network (Wang et al., 2005; Gooding et al., 2006); or in the alertness network (Nestor et al., 2007). The interpretation of these results is based on statistical significance criteria. However, none of these studies assessed the clinical significance of their results (Zakzanis, 2001).

From a clinical perspective, statistical significance might not be a sufficient criterion. In this sense, Cohen (1988) proposed that the d *(delta)* statistic might help establishing a clinical decision criterion based on the differences in a variable measured in two groups of participants. Cohen's d is defined as the distance in standard deviation units between the means of two groups. From this statistic, a measure of the degree of overlap between distributions can be obtained (the overlap statistic *OL%*). A larger value of d implies a lower degree of overlap between distributions. Cohen (1998) distinguishes between a small effect size (d= .25) reflecting an overlap of 82%; a medium effect size (d= .50) reflecting an overlap of 66.6%; a large effect size (d= .80) reflecting an overlap of 52.6%; and an extra-large effect size (*d*= 1.25) reflecting an overlap of 36.25%. In this manner, the overlap between two distributions is inferior to 50% only with large values of *d*, which prevents to overcome the randomness that occurs when sorting of participants into patients and controls based on their execution on a specific task. Therefore, this statistic is independent of sample size.

We assessed the clinical significance of the results reported by Wang et al., (2005), Gooding et al., (2006), and Nestor et al., (2007). Specifically, *d* scores were obtained in order to learn whether the differences in execution of the ANT between schizophrenia patients and controls were significant from a clinical point of view. We established a Cohen criterion by which significant differences between groups must reach at least a large effect size (*d=.80*) to be considered clinically significant. Wang et al., (2005) and Gooding and et al., (2006) studies suggested that schizophrenic patients showed a specific deficit of the anterior network. However, there were no clinically significant differences to support this conclusion. On the other hand, Nestor et al., (2007) results suggested that schizophrenic patients showed a deficit in the alertness network. Again, no clinically significant differences were observed. In summary, none of these studies offers clinically significant differences in support of specific attentional deficits. (see annex 1).

Thus, either the ANT does not allow discriminating the attentional profile of schizophrenic patients, or these patients' attention is simply not impaired, as Artacho et al. (submitted) observed in Multiple Sclerosis patients. It is also possible that the heterogeneity of symptoms and syndromes in schizophrenic patients explains the lack of consistency in the results reviewed above.

Schizophrenia is a heterogeneous disease (Bentall, 1990; Bentall, Kinderman, & Kaney, 1988; Ruiz-Veguilla et al., 2008). However, the studies just reviewed lack an explicit characterization of the precise relation between the different types of schizophrenic symptoms and syndromes, and the possible specific attentional deficits related to them. Therefore, a matter of the utmost importance when studying the functioning of the attentional system in schizophrenia is to characterize which specific psychotic symptoms are associated to specific deficits in the functioning of Posner's attentional networks.

The general aim of the present work was to evaluate the functioning of the attentional system in schizophrenic patients by means of the ANT task. Specifically, we wanted to ascertain whether specific types of schizophrenic syndromes (positive, negative of mixed) were associated to specific deficits in the three attentional networks in Posner's model. This classification in terms of positive and negative syndromes rests on the idea that symptoms that are predominant during the attentional assessment will be the most determinant when extract conclusions about the patients attentional profile.

Method

Participants

All of the human data described in this study has been obtained in compliance with the Helsinki declaration.

Overall, 52 people took part in the study. The clinical group was formed by 26 participants (14 men, 12 women), diagnosed with schizophrenia according to DSM IV criteria (APA, 1994). Their ages ranged from 15 to 52 years-old. None of the patients had been diagnosed more than five years earlier, datum corroborated by the patients' clinical history and information provided by their relatives. The control group was composed of 26 healthy participants (15 men, 11 women). Their ages ranged from 18 to 35 years-old. All patients were hospitalized in the psychiatry area of the «Complejo Hospitalario de Jaén» (Spain) during the course of the study. Every patient underwent a semi-structured interview including the modules of psychotic symptoms and mood state of the SCID (Spitzer et al., 1996). The presence and intensity of psychotic symptoms was assessed with the PANSS scale (Kay et al., 1987; Peralta & Cuesta, 1994). All participants had normal or corrected to normal vision. Participants met the following inclusion criteria: absence of acquired brain injury, absence of mental retard, and no evidence of drug use during the development of the study. The control group was composed of local participants who were paid for their collaboration.

Procedure

Clinical and demographic information on the patients was obtained by sanitary personnel of the Hospital's psychiatric area. The assessment of the patients' psychotic symptoms was done upon their arrival to the Hospital, by means of the PANSS scale. All participants in the study carried out the ANT task.

Materials

The PANNS (Positive and Negative Syndrome Scale) is composed of 30 items evaluating the intensity of 30 psychotic symptoms. Of the 30 symptoms, 7 constitute the positive scale (PANSS-P), 7 the negative scale (PANSS-N) and the remaining 16 the general psychopathology scale (PANNS-PG). In addition to the three scales evaluating each of the three dimensions, there is a fourth scale, referred to as the compound scale (PANSS-C). The compound scale is used to assess the predominance of positive over negative symptoms and vice-versa. This scale permits the characterization of the schizophrenic syndrome as positive, negative or mixed, depending on the predominance of one type of symptoms over the other. When the syndrome is mixed, the scores on the positive and negative scales are very similar. The PANSS has been validated in a Spanish population of schizophrenic patients (Peralta & Cuesta, 1994).

The ANT was used to assess the functioning of Posner's three attentional networks (alertness, conflict and orientation). The E-prime software (Schneider et al., 2002) was used to present the task and collect responses. Stimuli were presented in a laptop screen located at approximately 45 cm. from participants. The target was an arrow pointing left or right appearing on the center of the screen. The task was to identify as soon as possible the direction to which the target pointed. Responses were made by means of the «v» (left) and «n» (right) keys of the keyboard. Each trial started with the presentation of a fixation point on the center of the screen for 400 to 1600 ms. After the fixation point, warning signals were presented during 100 ms. This warning signal could appear in the centre of the screen («non-spatial» or «central» condition), on one side of the screen («spatial» condition), on both sides («double signal» condition), or it could not appear at all («no signal» condition). Thus, the difference in RT between the «no signal» and «central» conditions reflected the effect of alertness; while the difference between the «double signal» and «spatial conditions» allowed us to measure the effect of orientation. The warning signal was followed (after 400 ms) by the target, an arrow located on the centre of the screen which may point left or right. Importantly, this target is flanked by two additional arrows, one below and one above the target. Participants are then required to indicate the direction in which the target arrow is pointing (by pressing the corresponding button in a mouse. The flanker arrows may point in the same direction as the target arrow («congruent» condition), in the opposite direction («incongruent» condition), or they may not point in any direction («neutral» condition). This manipulation of congruence allowed us to measure interference effects, which are related to the control function of attention. Therefore, the ANT provided three attentional measures which are often orthogonal, that is, they do not correlate with each other. The trial ended after participants made their response or after 1700 ms elapsed.

Each experimental session involved a practice block comprised of 24 trials, and three experimental blocks comprised of 96 trials each (48 conditions: 4 types of warning signal × 2 stimulus locations × 2 stimulus directions × 3 conditions of congruence; two repetitions). The efficiency of the three attentional networks was calculated from the latency of responses in the different experimental conditions (12 conditions: 4 types of warning signal × 2 stimulus locations × 2 stimulus directions × 3 conditions of congruence).

Data analysis

Means, standard deviations and *d* of Cohen (Cohen, 1988) in the three attentional networks were calculated in schizophrenic and control groups, *d* scores were obtained in order to learn whether the differences in execution of the ANT between groups were significant from a clinical point of view. We established a Cohen criterion by which significant differences between groups must reach at least a large effect size (*d= .80*) to be considered clinically significant. From this statistic, a measure of the degree of overlap between distributions of two groups can be obtained (the overlap statistic *OL%*). A larger value of *d* implies a lower degree of overlap between distributions. Cohen (1998) distinguishes between a small effect size (*d*= .25); a medium effect size (*d*= .50); a large effect size (*d*= .80); and an extra-large effect size (*d*= 1.25).

Results

Demographical and clinical information

Table 1 summarizes the main clinical and demographical characteristics about the participants in this experiment. As can be seen, no significant differences between the patient and control groups regarding age, sex or educational level were observed. The average score for the patients in the PANSS scale was of 20.19 points in the positive scale (range: 7 to 49 points); 18 points in the negative scale (range: 7 to 49 points); and 36.19 for the general psychopathology scale (range: 16 to 112 points). Finally, the compound scale reveals that 10 out of the 26 schizophrenic patients met the criteria for a positive syndrome diagnosis, 5 for negative syndrome and 5 for mixed syndrome. The group with most participants was the positive syndrome group (n= 10). We were interested in determining whether this sub-group exhibits any attentional differences with the control group and negative syndrome group in order to learn if these patients show a specific attention profile.

ANT results

d scores were obtained in order to learn whether the differences in execution of the ANT between all sample of schizophrenia patients and controls and between positive syndrome group and controls were significant from a clinical point of view.

When ANT results of the all sample of schizophrenic patients was compared with the control group (see table 3), the alertness effect was larger for the patient group. However, the differences were not clinically significant (*d*= .34). The pattern of results for the orientation network was opposite to that of the alertness network, the effect size was small (*d*= .24), that is, the effect was smaller for the patient group. Regarding the conflict network, schizophrenic patients showed a larger interference effect. Again, a medium effect size (*d*= .51) revealed that this difference was not clinically significant. Overall RT was much larger for patients compared to controls with an extra-large effect size (*d*= 1.94). Given that overall RT is much larger for the patient group it is more adequate to use ratio scores to observe the specific effects of each network (Wang et al., 2005; Nestor et al., 2007). The clinical significance for the ratio scores for the alertness and conflict networks was almost negligible (*d* alertness= .04; *d* conflict= -.18). The effect for the orientation network was *d*= .69, reflecting a medium effect size according to Cohen's criterion. In summary, the patients and control group's performance did not differ significantly in any of the three networks.

When the ANT performance of the three subgroups of patients was compared (see table 3), results showed that the highest effect of alertness was observed in the negative syndrome subgroup, tough it was very similar for the other two subgroups. However, the pattern of results for the orientation and conflict effects was different. The positive and negative subgroups showed similar effects and the mixed syndrome group showed the highest effect for these two networks. In any case, there was not any clinical difference (not a large effect size) between the different subgroups of patients for any of three networks.

Finally, *d* scores were obtained for the comparisons of the positive syndrome sub-group with the control and with the negative syndrome sub-group. Only two comparisons showed a large effect size: positive syndrome with control (overall RT; *d*= 1.97); and ratio scores for the orientation network (*d*= -.84). These

Table 1
Means and standard deviations for the main demographical and clinical characteristics

	Patients (N= 26)	Controls (N= 26)
Age	31.6 (9.8)	28.2 (4.5)
Sex	14 Men/12 Women	15 Men/11 Women
Years of education	12 (3.4)	14 (6.2)
PANSS positive dimension score	20.19 (5.65)	–
PANSS negative dimension score	18.00 (8.18)	–
PANSS psychopathology dimension score	36.19 (10.16)	–

Table 2

ANT behavioral data for control subjects and the all sample of schizophrenic patients, positive, negative, and mixed syndrome subgroups presented as mean and standard deviations for the latencies of responses in the seven experimental conditions

	Control subjects N= 26		**Schizophrenic patients N= 26**		**Positive syndrome N= 10**		**Negative syndrome N= 5**		**Mixed syndrome N= 5**	
Time responses	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
No signal	544.15	54.90	766.12	169.93	713.36	165.51	645.45	76.36	812.9	122.68
Double signal	511.21	54.57	717.70	156.76	747.84	157.48	719.83	191.59	849.98	118.92
Central signal	524.98	59.79	727.61	166.87	700.61	158.17	633.33	70.57	803.22	110.09
Spatial signal	481.75	58.42	692.84	156.28	708.19	163.58	641.51	58.36	815.73	132.81
Neutral	478.69	51.59	663.26	135.71	687.75	177.57	615.4	79.02	769.42	122.77
Congruent	478.72	53.71	687.37	163.61	652.9	129.48	580.06	61.13	757.95	89.14
Incongruent	592.44	73.85	838.42	216.90	681.64	151.34	604.11	69.04	765.96	119.22

Table 3

ANT behavioral data for control subjects and the all sample of schizophrenic patients, positive, negative, and mixed syndrome subgroups presented as mean and standard deviations for the networks effects (alertness, orientation and conflict)

	Control N= 26		**Schizophrenic patients N= 26**		**Positive syndrome N= 10**		**Negative syndrome N= 5**		**Mixed syndrome N= 5**	
Time responses	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Alertness effect	32.94	19.21	48.42	71.88	47.23	42.39	86.49	173.65	46.77	38.59
Ratio	0.064	0.038	0.067	0.10	0.07	0.06	0.12	0.25	0.06	0.04
Orientation effect	43.23	30.16	34.77	38.96	20.45	39.72	26.1	22.26	46.31	31.55
Ratio	0.084	0.059	0.047	0.046	0.03	0.06	0.04	0.04	0.06	0.04
Conflict effect	113.72	47.59	151.05	97.98	132.99	118.72	119.81	78.05	162.13	97.47
Ratio	0.219	0.084	0.202	0.114	0.17	0.13	0.18	0.18	0.19	0.1
Overall RT	515.99	55.22	727.62	162.71	737.17	165.52	645.45	76.36	812.9	122.68
Overall accuracy	95.64%	1.80	94.58%	6.81	95.0%	4.73	97.4%	2.41	92.2%	8.24%

APPENDIX 1

Table 4

Mean and standard deviation for the different conditions Wang et al (2005). both in RT and accuracy measure in the three attentional networks. Overall accuracy and RT are also offered for both experimental groups. In the last column, Cohen's *d* for each type of score is offered. Significant differences are marked with a «*» sign

	Patients		**Controls**		
	Mean	S. D.	Mean	S.D.	*d*
Alertness effect	32	4.10	31	3.52	0.03
Ratio	.042	.005	.044	0.005	0.05
Orientation effect	44	4.41	54	3.45	0.29
Ratio	0.57**	.006	.078	0.004	0.51
Conflict effect	153**	10.03	99	4.33	0.76
Ratio	.193**	.011	.144	0.006	0.65
Overall RT	803**	19.85	696	16.78	0.68
Overall accuracy	95%**	0.92	98%	0.33	0.46

* $p<.05$; ** $p<.01$. Ratio scores are obtained dividing RT for each condition by the overall RT. This measure is useful as an index of the three networks' efficiency when the RT differences between groups are very large (Wang et al., 2005; Nestor et al., 2007)

APPENDIX 1

Table 5

Mean and standard deviation for the different conditions, both in RT and accuracy measures in the three attentional networks (Gooding et al., 2006). Cohen's *d* for each type of score is shown in the last column

	Patients		**Controls**		
	Mean	**S.D.**	**Mean**	**S.D.**	**d**
Alertness effect	13.23	6.08	11.47	6.32	0.05
Orientation effect	85.0	7.61	92.07	7.92	0.18
Conflict effect	128.91	9.92	108.44	10.32	0.40

APPENDIX 1

Table 6

Mean and standard deviation in RT and accuracy for the three networks (Nestor et al., 2007). Cohen's *d* for each score is shown on the rightmost column. Only ratio scores are shown as only these showed significant differences

	Patients		**Controls**		
	Mean	**S.D.**	**Mean**	**S.D.**	**d**
Alertness effect	.034	.051	.059	.035	0.58
Orientation effect	.107	.049	.096	.046	0.23
Conflict effect	.183	.132	.233	.079	0.37

differences indicate that patients in the positive syndrome group are generally slower to respond and that they show a significantly smaller effect of orientation respect to the control group.

Discussion

Our results suggest that schizophrenic patients do not show clinically significant deficits in any of the three attentional networks described in Posner's model when compared with the control group. None of the comparisons between patients and controls produced a large effect size in any of the three proposed networks. Therefore, from a clinical point of view it cannot be asserted that schizophrenic patients exhibit specific attentional deficits. Our results coincide with those of the review offered above as in none of the reviewed works clinically significant differences were observed for any of the three networks. Moreover, these studies reported contradictory results regarding the efficiency of the attentional networks. Wang and Gooding studies suggested that schizophrenic patients show less efficiency in the conflict network, whereas Nestor and colleagues report less efficiency in the alertness network. In our study, the lower efficiency was observed in the orientation network. Nonetheless, after dividing the results by syndrome we observed that positive syndrome patients showed less efficiency than controls in the orientation network, and this result was clinically significant. This suggests that positive symptoms are most likely related to the orientation network, though more research is needed on the matter.

In light of our results and those of the reviewed studies the ANT does not seem to be a sensitive enough task when evaluating specific attentional deficits on schizophrenia. Nevertheless, when patients are classified according to their psychotic symptoms, the ANT showed some sensitivity to these patients' attentional profile. Generally, patients show a tendency (not clinically significant) to exhibit a larger effect of alertness than the control group, but mostly in the negative syndrome sub-group; they also show a lower effect of orientation in the positive and negative syndrome sub-groups (clinically significant only for the positive syndrome sub-group); and a larger effect of conflict (mainly in the mixed group). Overall RT is consistently larger for all the clinical sub-groups than for the control group but this difference is larger for the mixed sub-group. This latter sub-group is significantly less accurate, slower and subject to larger interference effects than the control group. In summary, patients are equally accurate but slower than controls and they exhibit some attentional deficits specific for the type of syndrome.

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