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Auditory Discrimination, Attention, Learning, and Memory in Paranoid Schizophrenics

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The present research was designed to assess auditory discrimination, attention, memory, and learning in paranoid schizophrenic patients using a dichotic listening procedure consisting of attending to a signal or a story channeled only to one ear. A sample of 24 paranoid schizophrenics and 24 normal controls volunteered. In Experiment 1, 12 schizophrenics and 12 controls attended to the signal while shadowing the story. The task of the other 12 clinical and 12 normal subjects in Experiment 2 was identical to Experiment 1 with the exception that the subjects did not shadow the story. In each experiment, subjects completed three trials as well as three evaluations of the story. The results indicated that schizophrenics showed substantial attentional deficits in comparison to normal controls.

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Schizophrenia is undoubtedly one of the most serious and complex multifactorial mental disorders. The problem affects approximately 1% of the general population (Regier, Boyd, Burke, Rae, Myers, Kramer, Robins, George, Karno, & Locke, 1988; Strauss & Carpenter, 1981) while approximately 50% of the patients hospitalized in mental institutions (especially state facilities) are diagnosed as schizophrenics (Curran, Monti, & Corriveau, 1982). However, despite the importance of this problem and the vast interest and effort given to its clarification, the disorder is still little understood. The explanations about its etiology and nature are not only heterogeneous but are essentially based on clinical studies.

A perusal of the literature on schizophrenia reveals that practically all investigators agree that the alterations on cognitive processes (mainly disorders of thinking, attention, and information processing) are central to schizophrenia, while the affective and motor components are considered secondary. Similarly, cognitive alterations are fundamental to all diagnostic criteria (American Psychiatric Association, 1988; Bleuler, 1950; Carpenter, Strauss, & Bartko, 1973; Meehl, 1962; Spitzer, Endicott, & Robins, 1975; Taylor & Abrams, 1975; Schneider, 1976; Strauss & Carpenter, 1981). Although there is a substantial body of literature on cognitive processes in schizophrenia, practically all the studies have considered only one of these processes (usually, attention) and there are no investigations dealing simultaneously with other basic cognitive processes.

In previous research on the role of attentional processes in the learning of verbal instructions (Catena & Godoy, 1985), a dichotic listening procedure that combined the presentation of verbal and nonverbal stimuli was successfully developed and applied to nonclinical subjects. This procedure was adapted to clinical populations (basically to decrease the number of trials), and subsequently applied to paranoid schizophrenics.

EXPERIMENT 1

The purpose of this experiment was to compare auditory discrimination, as well as attentional and memory processes between paranoid schizophrenic and normal samples. The auditory discrimination was evaluated by a signal-detection task, which consisted of the presentation of two signals of different durations in one ear while simultaneously presenting a brief story to the other ear. Posttesting evaluation of the story allowed for the determination of attentional and memory capacity. This procedure was repeated three times to evaluate the learning process.

Method

Subjects. Twenty-four male and female adults between 17 and 48 years of age volunteered. Twelve inpatients (six males and six females) from an acute psychiatric ward that were diagnosed as paranoid schizophrenics by a doctorate level, board-certified psychiatrist using the International Classification of Disease 10th revision (World Health Organization, in press) criteria. They were diagnosed, selected, and referred between the third and fifth days of the onset of crisis (or exacerbation of symptoms for those with prior history) by the Chief Psychiatrist of the Psychiatric Unit of "Princesa de Espana" Provincial Hospital, in Jaen (Spain). All patients had been placed on standard neuroleptic medication protocols as all were exhibiting florid symptoms of schizophrenia. The present hospitalization was the first for the majority of the patients. The control subjects were normal adults matched for age, sex, and sociocultural levels. The demographic characteristics for both samples are shown in Table 1.

Apparatus. Stimulus materials consisted of a tone of different durations (250 msec: "short signal"; 280 msec: "long signal") produced by an auditory generator and controlled by a stimulus programmer. The sequence for each presentation was long-short-long-short-short-long. The other stimulus, a story of an elderly shoemaker working in his shop, lasted for 1 minute and 42 seconds. Both the story and test words were recorded in a soft female voice, selected from 20 tape-recorded voices on the basis of scores by several independent judges.

The apparatus consisted of a custom programmable auditory generator that permitted the presentation of auditory stimuli between 20–20000 Hz at intensity of 0–120 db, a custom twelve-channel stimulus programmer with error margin of .01%, a Technics stereo cassette deck (model RS-M 240X) with high-channel separation, a pair of Sennheiser stereo headphones (model HD-400) and Emerson Cr02 tapes.

Procedure. The story was presented in one ear while the auditory tones were simultaneously presented to the other ear. The clinical subjects were ran-

TABLE 1
Demographic Characteristics of the Subjects

	Experiment 1		Experiment 2	
	Schizophrenics	Normals	Schizophrenics	Normals
N	12	12	12	12
Sex (male/female)	6/6	6/6	6/6	6/6
Age				
range	17–48	18–48	16–52	16–55
mean	29.41	30.33	32.08	31.25
Educational level				
EGB (High School)	11	11	11	11
BUP (College)	–	1	1	1
Post-Graduate Studies	1	–	–	–

domly assigned to two groups of six subjects each. One group (attentive) had to attend to the story while ignoring the tones, and the other group (nonattentive) were instructed to report if the tone presented was short or long, while ignoring the story. The nonattentive group received a training trial with tones before the task was initiated.

Once this task was completed a series of 54 recognition test words were presented to the subjects via headphones, in which half of the words were from the story and the other half were novel. The idiomatic frequency, orthography, and semantic category of the novel words were matched to the original ones. The interword interval was four seconds. For each test word, the subject had to state whether they recalled each word. Test words were presented in a random order. The sequence of listening, and then evaluating, was repeated twice more. That is, each subject received three trials and three evaluations. A pilot study revealed that more trials produced fatigue and a sharp drop in performance in the clinical but not control subjects. The series of word presentation were different for each of the three evaluations.

The ear to which the story was presented was counterbalanced with the aim to control potential handedness and hemispheric dominance. Ear asymmetries due to increased laterality in schizophrenics have been reported in studies using dichotic listening procedures (e.g., Gruzelier & Hammond, 1980; Lerner, Nachshon, & Carmon, 1977) and other tasks involving intra- and interhemispheric information processing (e.g., Flor-Henry, 1978; Gur, 1978, 1979; Hunter & Green, 1985).

The control subjects participated in the same procedure. All subjects were informed that they were participating in a study of hearing and memory.

Dependent variables. The measure used for the evaluation of learning was the percentage of correct responses [(correct acceptance+correct rejection)/total of words]. For assessing auditory discrimination task performance (i.e., the short-long task), the discriminative index d' was used ($d'=Z\text{far}-Z\text{hr}$; Zfar=the standard scoring of the false alarm rate, that is, saying short to a long signal; and Zhr the standard scoring of the hit rate, that is, saying short to a short-signal).

Results

The results for Experiment 1 are shown in Figure 1. The attentive subjects, both clinical and normal groups, showed an increment in learning of the story, with clinical vs. normal group differences being found only on the first trial. In the nonattentive groups, learning increments were found only in the normal subjects with no between groups differences noted.

A mixed 2×2×3 ANOVA ($A\times B\times(C\times S)$) in which A is a between-groups factor (two levels: schizophrenics-normals), B is a between-groups

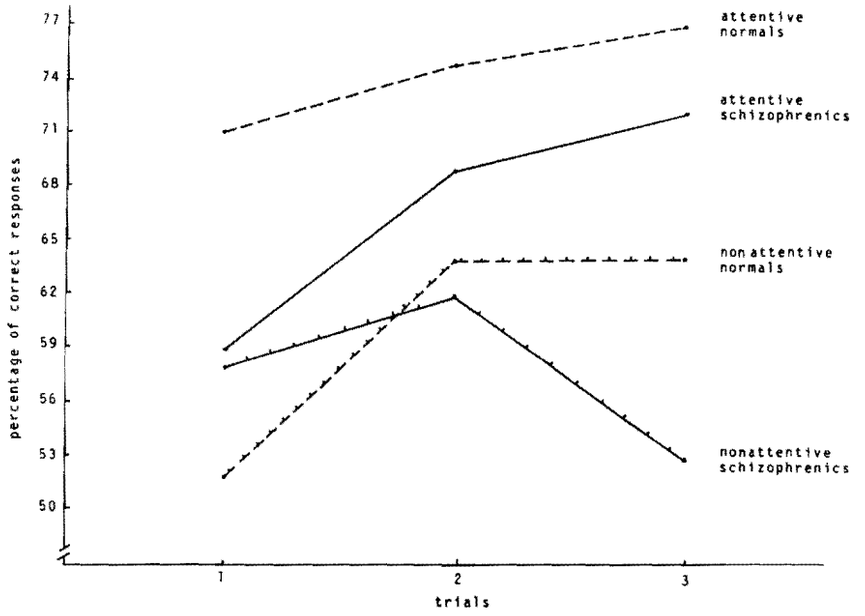

FIGURE 1. Experiment 1. Differences between trials for the different groups.

factor (two levels: attentive-nonattentive), C is a within-subjects factors (three levels: 1st-2nd-3rd trial), and S are subjects, on the percentage of correct responses was performed.

This analysis indicated statistically significant differences for the schizophrenic vs. normal factor ($F(1, 20)=6.172$, $p<.05$), the attentive vs. nonattentive factor ($F(1, 20)=35.658$, $p<.01$), as well as the trials factor ($F(2, 40)=8.850$, $p<.01$), and an $A\times B\times C$ interaction ($F(2, 40)=4.347$, $p<.01$) (see Figure 1).

The analysis of simple main effects of second-order interactions revealed that on the 1st trial there were statistically significant differences between attentive schizophrenics and attentive normals ($F(1, 10)=15.768$, $p<.01$) but not between the nonattentive subjects. Also, for the schizophrenic groups there were no significant differences between attentive and nonattentive subjects. The differences between attentive and nonattentive normals were significant ($F(1, 10)=27.762$, $p<.01$ (Figure 1). In the 2nd trial, statistically significant differences between attentive and nonattentive subjects ($F(1, 20)=7.812$, $p<.01$) were noted. For the 3rd trial, there were significant differences between schizophrenic and normal subjects ($F(1, 20)=6.365$, $p<.05$) and between attentive and nonattentive subjects ($F(1, 20)=26.364$, $p<.01$) (Figure 1).

For the attentive subjects, significant differences were seen between schizophrenics and normals ($F(1, 10)=5.447$, $p<.05$) and between the trials ($F(2, 20)=14.515$, $p<.01$). Analyses revealed that the 1st and 2nd trials were significantly different ($F(1, 10)=14.248$, $p<.01$) and the 1st and 3rd, but not the 2nd and 3rd trial (Figure 1). Within the nonattentive subjects significant differences were found.

For the schizophrenic subjects, significant differences between attentive and nonattentive subjects were only found in the 3rd trial ($F(1, 10)=14.806$, $p<.01$). For attentive schizophrenics, however, the analysis revealed a linear data trend ($F(1, 5)=16.041$, $p<.05$) while no differences in the nonattentive schizophrenics between trials were found (Figure 1). For the normal subjects, significant differences between attentive and nonattentive ($F(1, 10)=31.610$, $p<.01$) and between trials ($F(2, 20)=11.547$, $p<.01$) were observed. The comparison between the 1st and 2nd trials for these subjects ($F(1, 10)=14.632$, $p<.01$) as well as the 1st and 3rd trials, but not between the 2nd and 3rd trials (Figure 1).

Analysis of the auditory signal discrimination task was a mixed ANOVA ($A\times(B\times S)$) in which A was the between-groups factor (two levels: schizophrenics–normals), B was the within-subjects factor (three levels: 1st–2nd–3rd trials), and S factor represented subjects. This analysis revealed no statistically significant differences.

EXPERIMENT 2

The present experiment was designed to evaluate whether the results of Experiment 1 could be attributed to the effect of instructions to shadow the story. Simultaneously, an attempt was made to assess how well clinical subjects followed the experiment's instructions.

Method

The subjects in this experiment were 24 male and female adults (12 schizophrenics and 12 controls) between the ages of 16 and 55 with the same demographic characteristics of the previous experiment (Table 1). The stimulus material and apparatus were described in Experiment 1. The only procedural difference of this experiment was that the subjects of attentive groups did not have to shadow the story.

Results

Figure 2 suggests that only normal subjects were able to learn the story and that learning was complete by the second trial.

This visual impression was confirmed by an ANOVA $2\times2\times(3\times6)$. This

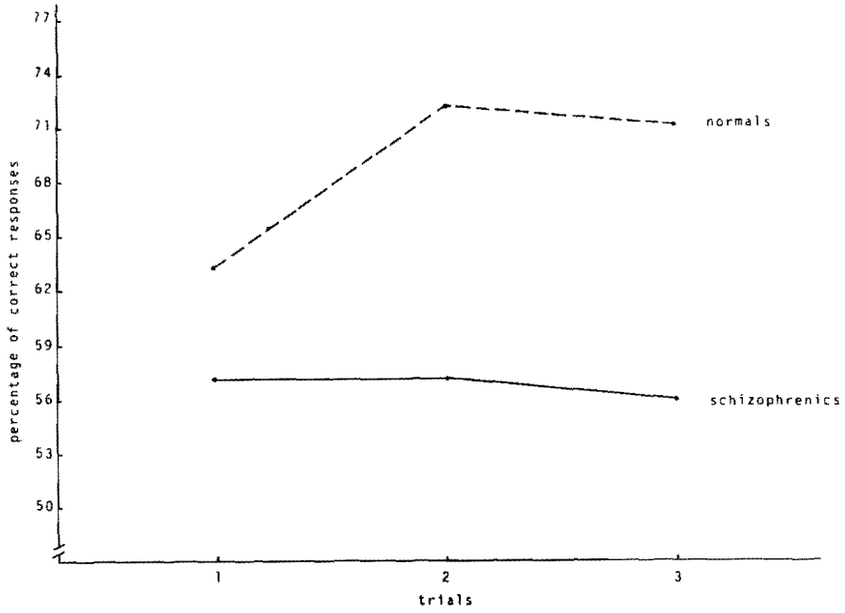

FIGURE 2. Experiment 2. Differences between trials for the different groups.

analysis revealed statistically significant effects for schizophrenic versus normal ($F(1, 20)=15.710$, $p<.01$), and for the trials factor ($F(2, 40)=6.049$, $p<.01$ as well as a clinical group by trials interaction ($F(2, 40)=5.881$, $p<.01$) (Figure 2).

The simple main effect analysis on the first order $A\times C$ interaction revealed that there was a significant quadratic component for the normal subjects ($F(1, 22)=7.700$, $p<.05$) and that there were no other trends, neither linear nor quadratic for the schizophrenic subjects (Figure 2).

For the analysis of the signal discrimination task, a mixed ANOVA ($A\times(B\times S)$) was completed in which A was a between-groups factor (two levels: schizophrenics–normals), B was a within-subjects factor (three levels: 1st–2nd–3rd trials), and S were subjects, on signal detection theory index d'. Statistically significant differences were also not obtained for this analysis.

DISCUSSION

The purpose of this study was to investigate the auditory discrimination, attention, learning, and memory processes in paranoid schizophrenics. The results indicated that the paranoid schizophrenics were different than normals in some of these basic cognitive processes.

There were significant differences between attentive normals and attentive schizophrenics but not between nonattentive normals and nonattentive schizophrenics. This initial finding suggests that there is an attentional deficit since these differences appeared when an attentional factor variable was introduced. These findings do not appear to be attributable to a memory deficit as the nonattentive schizophrenics recalled as well as the nonattentive normals. Attentional deficits have been reported by several authors (Asarnow, Nuechterlein, & Marder, 1983; Cornblatt, Lenzenweger, Dworkin, & Erlenmeyer-Kimling, 1985; Nuechterlein, Edell, Norris, & Dawson, 1986; Oltmanns & Neale, 1975; Payne, Hochberg, & Hawks, 1970; Schneider, 1976; Walker, 1981).

Nevertheless, when we consider the attentive and nonattentive schizophrenics and the attentive and nonattentive normals significant differences were observed. An attentional deficit was observed in the first trial. In addition, this deficit is so accentuated that the attentive schizophrenic could be differentiated from the nonattentive one, at least on the first trial. By the second and third trials there were differences between attentive and nonattentive subjects (second trial) and between schizophrenics and normals and attentive and nonattentive subjects (third trial). However, in the second trial the performance of the schizophrenics and normals were very similar. The only difference on this trial was seen between attentive and nonattentive subjects. Similar patterns were noted on the third trial with the exception that on this trial, we find differences between schizophrenics and normals due to the decline in the performance (although it is not statistically significant) of the nonattentive schizophrenics. (This decline may be attributable to fatigue of clinical subjects).

The difference between subjects is clearly in the first trial. An explanation for this may be found in comparing the attentive schizophrenic to the nonattentive normal. Significant differences between schizophrenics and normals were found on the initial trial. As seen in Figure 1, the performances were parallel; the learning of attentive subjects is similar, the only differences between attentive subjects was the "baseline" level. In other words, we have no evidence (quite the reverse) of any differences in the process of learning. When we consider only nonattentive subjects no significant difference between schizophrenics and normals were found. This finding suggests that the major contributing factor causing group differences is an attentional deficit in the schizophrenic subjects.

When attention is focused only on the schizophrenic subjects significant differences exist only between the attentive and nonattentive subjects. That is, an attentive schizophrenic is similar to a nonattentive one in the initial trials. They differed only by the third trial because of a performance drop by the nonattentive schizophrenics on this trial. Essentially, the attentive and nonattentive schizophrenics were quite similar. However, the data for normals was different. The learning process was identical between attentive and nonattentive subjects, with the basal level difference. A difference in the amount of learning was observed, but not in the learning process. In summary, in this experiment we find a clear deficit of attention, and not in learning or recall.

In the second experiment the interaction showed that there is no improvement in the attentive and nonattentive schizophrenics during the trials, but there was clear improvement in the normals. The improvement shown by normals is similar to Experiment 1, the improvement increases from the first to second trial but not from the second to third trial. However, no differences between attentive and nonattentive normals were found. The fact that the attentional variable is not significant if no external control exists is interpreted to mean that in the subjects without this control may not have followed instructions. However, it is evident in this experiment (and Experiment 1) that the normal subjects but not the schizophrenics exhibited task learning.

Finally, the auditory discrimination did not appear to be different between types of subjects as no significant differences between schizophrenics and normals was found. However, this and other findings in these experiments could be affected by such variables as level of psychotic disorganization as well as neuroleptic medication (Gruzelier, 1978). Thus, future studies should take into account these and other demographic variables.

There are several general conclusions that may be drawn from the present study.

1. Auditory discrimination does not appear to be affected in schizophrenia.
2. It is essential to obtain objective evidence that the schizophrenic, at least the paranoid schizophrenic, is paying attention and following instructions.
3. The learning of nonshadowing attentive schizophrenics is similar to nonattentive schizophrenics.
4. In certain circumstances, the attentive schizophrenic, even when shadowing, behaves identical to the nonattentive one due to attentional deficits.
5. Normals, however, behave differently as the attentive and nonattentive subjects differ on the initial trial.
6. The nonattentive schizophrenic does not differ from the nonattentive normal, while the attentive schizophrenic does not differ from the nonattentive ones, they do differ from the attentive normal.
7. These findings are probably due to an attention deficit and cannot be

attributed to a memory dysfunction because the attentive schizophrenic does show recall during later trials and the amount of learning is similar to the normal subjects.

8. The learning process in the attentive schizophrenic is, however, similar to the nonattentive normal.

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