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Gaze direction determination in schizophrenia

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Abstract

It has been proposed that an impairment in gaze determination is responsible for the paranoid symptoms reported in schizophrenia. To address this, we examined the gaze discrimination system in schizophrenia. Thirty-two patients suffering from schizophrenia (20 patients with persecutory delusions and 12 patients without such delusions) were compared to 32 control subjects on two specific tasks. In the first task, the subjects had to determine whether 130 portraits were looking right or left. In the second task the subjects were asked to determine whether or not 130 portraits were looking at them.

The absolute threshold of difference used to investigate the influence of instruction on gaze discrimination did not show any difference between patients with schizophrenia, whatever paranoid or not, and control subjects. Paranoid patients, as well as controls, displayed a significantly finer discrimination threshold in the right vs. left judgment than in the self vs. non-self judgment. Subjects with schizophrenia were able to discriminate gaze direction in the two tasks, but they took significantly more time in the task requiring to determine the presence or the absence of a mutual gaze contact than in the other one, whereas controls took the same duration to elicit both tasks. These data are consistent with those reporting that perceptual abilities are spared in schizophrenia while delusions are related to an impairment of a higher level of analysis.

Keywords: Schizophrenia; Persecutory delusions; Perception; Gaze discrimination; Top-down processes; Psychophysics indicator

1. Introduction

Gaze is regularly described as inquisitive, menacing, or aggressive by schizophrenic patients suffering from paranoid symptoms. The causal relationships between the ability of these patients to correctly perceive others' gaze, and their feelings of persecution is currently discussed. Indeed the question has been raised as to whether these delusional feelings affecting paranoid patients could be the result of a gaze discrimination impairment (Rosse et al., 1994), or whether delusional ideas of reference and persecution could lead to misinterpretations of others' gaze (Franck et al., 1998). According to Baron-Cohen (1995), sensitivity to eye gaze relies on a specific cognitive module, the Eye Direction Detector (EDD) which includes three main functions. First, the EDD is involved in eye detection. Second, the EDD is used to establish gaze direction, and specifically, to compute

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whether the direction of gaze is toward us or toward another individual. Third, the EDD is implied in interpretation of gaze as seeing (Baron-Cohen, 1995). That is, it intervenes in the interpretation of others' intentions, and allows us to establish what others are interested in, wish, or think, when they look at something or at somebody.

Some neuroimaging and electrophysiological studies have revealed that the superior temporal sulcus is implied in gaze determination (Perrett et al., 1988; Campbell et al., 1990; Wicker et al., 1998). Anomalies of the superior temporal region have been identified in schizophrenia (Gur and Pearlson, 1993; McCarley et al., 1993; Zipursky et al., 1994). Taking these data into account, Rosse et al., 1994 have hypothesized that gaze discrimination should be abnormal in schizophrenia. Basically, according to this hypothesis, the impairment of an elementary perceptual ability — the faculty to correctly identify the gaze direction of others — could secondarily participate in the formation of delusional beliefs. Rosse et al. (1994) tested the ability of 24 schizophrenic patients, compared to 25 normal controls, to discriminate whether 40 photographic portraits looked at them or not. They found a bias towards directed gaze by the schizophrenic sample, and this was especially prevalent in the paranoid patients. The authors did not evaluate the patients ability to discriminate gaze direction in a neutral task; indeed their task implicated only a self-referential-judgment.

Alternatively, Franck et al. (1998) reported that expectations can modify perceptions. The top-down processing (Anderson, 1980) could take a part in the genesis of delusional beliefs (Fleminger, 1992). According to this hypothesis, patients with persecutory delusions experience the gaze of others directed at them secondary to their belief that they are being observed. This could be subsequent to their sensation of being the center of the events taking place around them. The sensation that events have significance only in relation to themselves not only creates an 'indescribable' experience (Spitzer, 1990), but also leads to more systematized delusions in an 'apophantic' phase (Conrad, 1958). Delusional themes are then self-referential and persecutory, during which patients often interpret others gaze as hostile. Franck et al. (1998) compared 22 schizophrenic subjects to 36 normal controls in a right vs. left gaze discrimination task using 30 portraits. The types of responses were not significantly different between the two groups of subjects. The authors concluded that gaze discrimination is unimpaired in schizophrenia and that an impairment affecting gaze interpretation rather than the elementary eye detection should explain the previous results. However, the authors did not use a self-referential-judgment to confirm their assumption and they did not study paranoid symptoms in their results.

The aim of the present study is to disentangle the perceptual and intentional mechanisms in the misperception of gaze in paranoid patients. In order to consider this particular question, it seemed necessary to take into consideration both the ability of patients to address a neutral question about gaze direction and an explicit question about mutual gaze using the same stimuli. A task divided in 2 sessions was conceived. In one session, subjects were required to determine the gaze direction of portraits looking either right or left. In the other session, subjects were required to determine if the same portraits were looking at them or not (self-referred judgment). Schizophrenia patients were divided into 2 groups according to their persecutory status. Performances of both patient samples were compared with each other and with normal controls. Finally, subjects' performances in the 2 sessions were compared.

The hypotheses of this study were that (1) patients with schizophrenia will demonstrate a normal ability to discriminate the direction of others' gaze in right vs. left judgment. Furthermore, this would correspond to the fact that the second function of EDD (Baron-Cohen, 1995) is spared, as evidenced by the results of Franck et al. (1998). And (2) the same patients, particularly patients with persecutory delusions, would demonstrate a greater tendency to interpret the direction of others' gaze as looking at them in self-referred judgments, that would correspond to an abnormal functioning of the third function of EDD.

2. Methods

2.1. Subjects

Thirty-two patients (27 males, 5 females; mean age:

33.7, SD 9.7) meeting DSM-IV criteria for schizophrenia and 32 normal controls (19 males, 13 females; mean age: 34.7, SD 11.0) were included in the study. Patients and control subjects were blinded to the purpose of the experiment. The study had been approved by the local ethical committee (CCPPRB Léon Bérard, Lyon). All the subjects provided written informed consent after a complete description of the study.

Patients were assessed using the Mini International Neuropsychiatric Interview (MINI) (Lecrubier et al., 1997) to systematically determine the presence of schizophrenia and to exclude concomitant severe substance abuse, medical or neurologic illness and head trauma. Control subjects were mainly recruited from maintenance staff of two hospitals. Patients with schizophrenia and control samples did not differ significantly in age, sex, laterality and educational level. Exclusion criteria in both groups included: visual and auditory disorders and age greater than 65 or less than 18 years.

Sixteen of the 32 patients were hospitalized at the time of the study. Fourteen patients met the criteria for paranoid schizophrenia, 1 for disorganized schizophrenia, 14 for undifferentiated schizophrenia and 3 for residual schizophrenia. All but 4 patients were right-handed according to the Edinburgh Inventory (Oldfield, 1971). The mean average duration of illness was 10.7 years (SD 8.5). All patients were clinically stable at the time of testing and were receiving antipsychotics. Medication averaged 18.0 mg haloperidol equivalents per day (SD 10.3).

The Birmingham Object Recognition Battery (BORB) (Riddoch and Humphreys, 1993) was used to assess patients' spatial perception abilities in 23 out of the 32 patients. The BORB investigates the ability to process basic features of simple or geometric pictures. The patients' performances were within normal range in the six tests used (Line Match Test A = 26.9; cut-off point 22; Circle Match Test A = 26.6, cut-off point 19; Line Orientation Match Test A = 23.6, cut-off point 18; Position of Gap Match Test A = 34.2, cut-off point 24; Minimal Feature View Task = 24.3, cut-off point 18.5; Item Match Task = 31.5, cut-off point 24).

All patients underwent clinical assessment with the Scale for Assessment of Positive Symptoms (SAPS; Andreasen, 1984) and the Scale for Assessment of Negative Symptoms (SANS; Andreasen, 1983). Mean scores were 25.2 for the SAPS (SD 11.8; range 8–60), and 42.6 for the SANS (SD 21.50; range 4–85). Patients were classified as paranoid or non-paranoid (See Table 1) according to their score on item 8 of the SAPS ('Persecutory delusions').

At the time of testing, 20 patients presented a persecutory score comprised between 1 and 5 and were considered as paranoid. The remaining 12 patients, scoring 0 on this item, were considered as non-paranoid. No differences between the two samples of patients were found on t-tests regarding age, educational level, laterality, disease duration, clinical features (SAPS and SANS total scores), medication and 4 tests from the BORB. Performances on the BORB Line Orientation Match Test (LOMT) and Minimal Feature View Task (MFVT) were significantly lower in non-paranoid than in paranoid patients (LOMT: $t = 2.3$, $df = 21$, $p = 0.03$; MFVT: $t = 2.2$, $df = 21$, $p = 0.04$) but still in the normal range.

2.2. Stimuli

Stimuli were 130 colored photographic portraits expressing neutral facial expression. All pictures were full-faced portraits of 10 models having brown eyes. This eye color is known to be well detected by the visual system because of the contrast between iris and sclera (Campbell et al., 1990; Anstis et al., 1969). Models were 5 females and 5 males, aged from 20 to 30 years. For each model, 13 pictures were taken with a digital camera (Fujix DS-300), each presenting one of 13 different directions of gaze (−30°, −25°, −20°, −15°, −10°, −5°, 0°, +5°, +10°, +15°, +20°, +25°, +30°; Fig. 1 represents a set of portraits). In other words, 10 × 13 portraits (10 for each gaze direction) were shown to the subjects. All pictures were standardized by using a graphic software package, so that all the faces were set into the same size. Slides (35 mm) were obtained from these pictures and projected on a white screen (200 × 180 cm). Displayed size of pictures was 70 × 80 cm.

2.3. Apparatus and procedure

The experiment was run on a personnel computer HP Kayak XA, controlling the data collection. A tachistoscopic presentation program ('Extended program Vienna Test System' of Dr Schufried Corp.) was

Table 1
Characteristics of normal controls and schizophrenic patients with and without persecutory delusions; means (SD)

	Paranoid patients ($n = 20$)	Non-paranoid patients ($n = 12$)	Normal controls ($n = 32$)
Age (years)	32.2 (7.1)	36.2 (13.0)	34.7 (11.0)
Gender:			
Male	16	11	19
Female	4	1	13
Educational Level (years)	10.7 (2.5)	9.7 (2.1)	10.5 (3.7)
Handedness:			
Right	17	10	30
Left	3	2	2
Illness Duration[a] (years)	9.6 (6.7)	12.5 (10.9)	–
Medication[b] (mg)	16.4 (7.7)	20.7 (13.6)	–
Total S.A.P.S.	23.8 (10.4)	27.5 (14.0)	–
Total S.A.N.S.	38.8 (21.4)	48.8 (21.1)	–
B.O.R.B.:			–
Line Match Test	26.4 (2.0)	27.9 (3.8)	–
Circle Match Test	26.7 (1.1)	26.3 (1.6)	–
Line Orientation Match Test	24.8 (2.6)	20.9 (6.0)	–
Position of Gap Match Test	34.9 (3.6)	32.4 (5.0)	–
Minimal Feature View Task	24.7 (0.6)	23.1 (2.9)	–
Item Match Task	31.4 (2.0)	31.8 (0.4)	–

[a] Time elapsed since onset of psychotic symptoms.
[b] Mean dose for the last month (haloperidol equivalents).

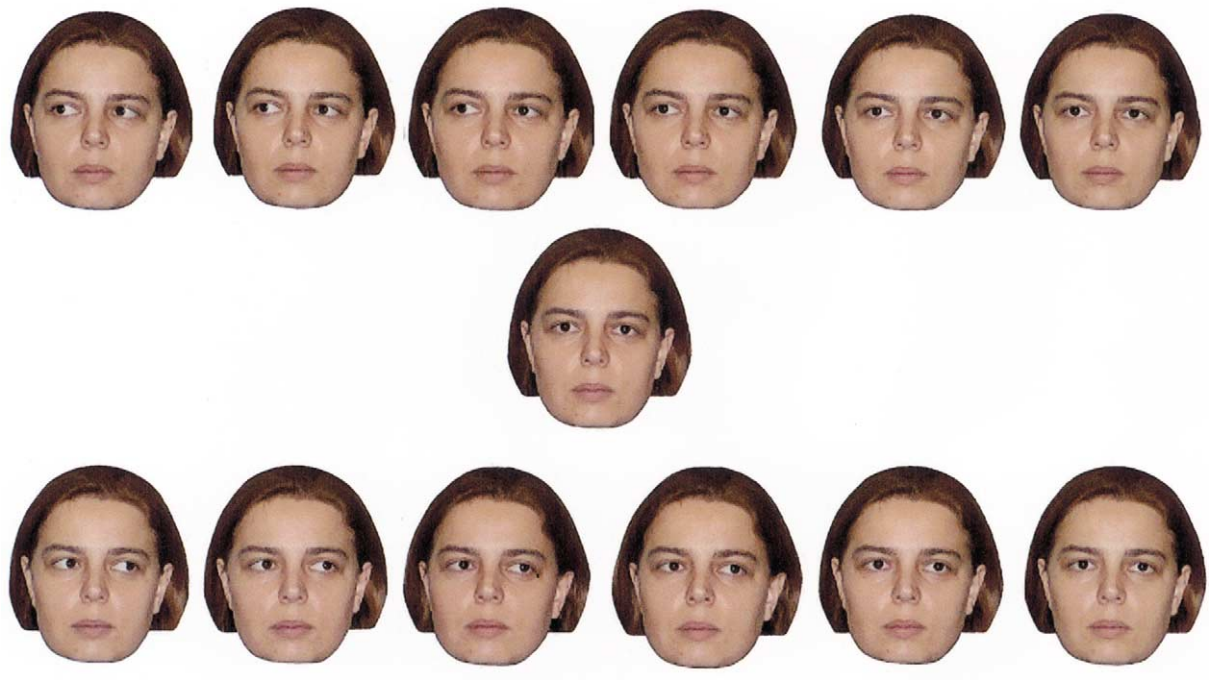

Fig. 1. An example of a set of 13 gaze directions: on the top line the gaze direction are from ‘ − 30° to −5°’, on the bottom line from ‘ + 30° to +5°’ and ‘00°’ in the center.

used. All subjects were tested individually in a silent and slightly dark room. Subjects sat at a distance of 200 cm in front of the screen. The experiment consisted in 2 sessions of 130 trials. In each trial, one picture was presented and the subject had to complete a judgment concerning the gaze direction of the portrait. The 2 sessions were fully identical with the exception of the regarding instructions provided.

In one session, subjects had to determine whether the gaze of the portrait was looking rightward or leftward. The instruction for the participants was the following: "In each trial, you are going to see one picture with an individual looking either left or right. You will have to discriminate whether the gaze of the picture is directed to your left or to your right by pressing a key situated on either side." A button box with 2 keys (1 on the left and 1 on the right) was used; subjects positioned their hands on this specific device.

In the other session, subjects were asked to determine as accurately as possible whether the portraits were looking at them or elsewhere. The instruction for the participants was as follow: "In each trial, you are going to see one picture, looking either at you or somewhere else. You will have to discriminate whether the gaze of the picture is directed to you or elsewhere. If the picture looks at you, press the nearest key from you; if the picture looks elsewhere, press the farther key from you" (self vs. non-self judgment).

Half of the subjects were instructed to begin the experiment with the gaze direction task followed by the self versus non-self judgment task. The other half, were instructed to perform the two tasks in reverse order. Time limits were not imposed, and the picture remained on the screen until a response was given. The display set presentation order for the 130 pictures was semi-randomized. Hence, the picture presentation order was first randomized and then separated in four blocks (A, B, C, D) and kept fixed. Blocks were alternated. This experiment was made of two sessions of 130 trials corresponding to two different instructions. The order of the presentations for the two sets of stimuli was reversed for the second presentation (i.e. ABCD for the first session and DCBA for the second session, or the other way round).

For each trial, we recorded both the nature of the response and the corresponding response time. For each subject, four practice trials were run before the experimental session in order to assess comprehension of the instructions as well as the subjects' ability to detect the pictures.

2.4. Data analysis

The nature of response was analyzed by using a Fechnerian psychophysics measure (Fechner, 1860; Gesheider, 1976). We computed the absolute difference threshold (AT) for each subject (Tiberghien, 1984, pp. 44–49). The AT is defined as the intensity of a stimulus so that it is perceived in 50% of cases. In the present experiment, the AT is the angular value (expressed in degrees) allowing subject to decide whether other's gaze is looking rightward or leftward in the first instruction, or whether other's gaze is looking at her/him or elsewhere in the second instruction.

Non-parametric tests were employed to analyze the nature of the responses. Different non-parametric tests were used to evaluate the effect of factors such as the between-group factor and the repeated factor instructions. The Wilcoxon's matched pairs test was used to test differences between instructions. The Kruskal–Wallis test was used for the comparisons of the three groups. The Mann–Whitney U test was used in order to compare the results of groups by pairs.

Analysis of variance was conducted on reaction times for a between-subjects factor (Groups), and two within-subjects factors (Gaze Orientations and Instructions).

3. Results

3.1. Analysis of the nature of responses

Table 2 indicates the stimulus value for AT as functions of groups and instructions. The Kruskal–Wallis analysis of ranks used to compare groups did not show any significant group effects between paranoid patients, non- paranoid patients, and normal controls ($H = 2.76, p = 0.25$). This means that the given value (in degrees) that was considered to represent an absolute threshold was not different for controls, paranoid, and non-paranoid patients.

The Wilcoxon test was used to evaluate the main effect of the two instructions for each group. The main effect of instructions was significant ($z = -5, 19, p <$

Table 2
Absolute thresholds (medians and interquartile deviations, in degrees) for angular discrimination of gaze of patients and normal controls

	Right vs. left		Self vs. non-self	
	Median	Interquartile deviation	Median	Interquartile deviation
Normal controls	2.2	1.4	5.5	3.0
Non-paranoid patients	2.1	1.3	4.3	4.8
Paranoid patients	2.3	1.1	5.8	4.5

0.0001) The right vs. left judgment had a smaller absolute threshold value than self vs. non-self judgment. The Wilcoxon test was used to look for the main effect of the two instructions according to the group of subjects via the modifications occurred on the psychophysics indicator. The analysis of the main effect of instruction in the non-paranoid group of patients was not significant ($z = -1.54$, $p = 0.12$). However this indicator was significant for paranoid patients ($z = -2.69$, $p = 0.007$). The paranoid patients had better absolute thresholds in right vs. left judgment than in self vs. non-self judgment. The examination of these indicators for the control group showed that the main effect of instructions was significant ($z = -4.06$, $p < 0.0001$). The control group also had better discrimination thresholds in right vs. left judgment than in self vs. non-self judgment.

The nature of responses reported by schizophrenic patients (paranoid or not paranoid) was compared to that of controls for each condition by means of Kruskal–Wallis tests. The Kruskal–Wallis analysis of ranks, used to compare the groups in right vs. left judgment, showed that there was no significant difference between schizophrenic and control samples ($H = 1.75$, $p = 0.42$). The Kruskal–Wallis analysis, used to compare the groups in self vs. non-self judgment, demonstrated that there was no significant difference between schizophrenic patients and control group ($H = 0.83$, $p = 0.66$).

The nature of responses reported by schizophrenic patients (paranoid or not paranoid) and controls was compared in right vs. left judgment and in self vs. non-self judgment by mean of Mann–Whitney tests. In right vs. left judgment, there was no significant difference between paranoid patients and non-paranoid patients ($U = 99$, $z = -0.24$, $p = 0.81$), between paranoid patients and controls ($U = 245$, $z = -1.15$, $p = 0.25$), and also between non-paranoid and controls ($U = 141.50$, $z = -0.96$ $p = 0.34$). The Mann–Whitney tests used to compare the groups in self vs. non-self showed that there was no significant difference between paranoid patients and non-paranoid patients ($U = 81.50$, $z = -0.18$, $p = 0.86$), between paranoid patients and controls ($U = 224.50$, $z = -0.50$, $p = 0.62$), and also between non-paranoid and controls ($U = 115.50$, $z = -0.95$, $p = 0.34$).

The psychophysics indicator was not correlated to neither the haloperidol equivalent nor the instruction.

In summation, the analysis of the response nature revealed that the instructions induced a difference of the AT for controls and paranoid patients. Paranoid patients, as controls, had finer threshold in right vs. left judgment than in self vs. non-self judgment. These groups are influenced by the instruction, while this is not the case for non-paranoid patients.

3.2. Analysis of reaction time (RT)

Mean response times according to groups and instructions are reported in Fig. 2; Table 3 gives response times for each gaze direction. Comparative statistics on reaction times were computed with a $3 \times 2 \times 13$ (group × instruction × gaze orientation) mixed analysis of variance, using Statview software. The overall main factors were significant. First, there was an effect of the 'Group', $F(2, 1586) = 319.54$, $p < .0001$. The non-paranoid schizophrenic patients were significantly slower than paranoid schizophrenic patients, $t(830) = 7.77$, $p < .0001$, respectively mean = 1529 ms (SD 880) vs. 1122 ms (SD 624). The non-paranoid schizophrenic patients were significantly slower than controls, $t(1142) = 22.33$, $p < .0001$, respectively mean = 1529 ms (SD 880) vs. 747 ms (SD 304). The paranoid schizophrenic patients were significantly slower than controls,

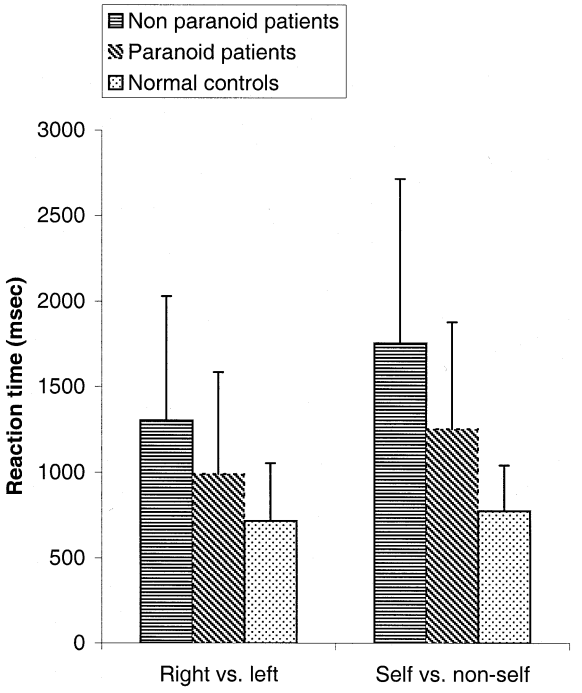

Fig. 2. Mean reaction times (SD) observed of schizophrenic patients and normal controls for the 2 instructions.

$t(1350) = 14.76$, $p < .0001$), respectively mean = 1122 ms (SD 624) vs. 747 ms (SD 304). Second, there also was an effect of 'Instructions'; responding to right vs. left judgment was significantly faster (912 ms SD 560.517) than responding to self vs. non-self judgment (1109 ms SD 685.997), $F(1, 1586) = 102.45$, $p < .0001$. Third, there was an effect of 'Gaze Orientation' where the subjects responded faster to gaze orientations close to −30° or +30 than to 0°, $F(1, 12) = 30.44$, $p < .0001$.

All two-way interactions were significant. The interaction between group and instruction was significant, $F(2, 1586) = 20.90$, $p = .0001$. While reaction times of control subjects did not differ between the 2 instructions (717 ms, SD 336, and 776, SD 266), patients did respond more slowly in self vs. non-self judgment than in right vs. left judgment. However, the non-paranoid patients were slower than the paranoid patients, in self vs. non-self judgment (respectively 1756 ms, SD 960, and 1253 ms, SD 627) and right vs. left judgment, (respectively 1302 ms, SD 727, and 990 ms, SD 594). The interaction between group and orientation was significant, $F(12, 1586) = 1.57$, $p = .0389$. According to gaze orientation, reaction times changed less for control subjects than for

Table 3
Reaction time (means, SD) for normal controls and patients as function of instructions and gaze directions

	Right vs. left		Self vs. non-self	
	Mean	S.D.	Mean	S.D.
Controls				
−30°	513	84	584	124
−25°	534	94	622	130
−20°	582	112	686	215
−15°	567	98	715	211
−10°	672	192	900	302
−5°	882	309	987	350
0°	1303	537	829	223
5°	1114	431	916	251
10°	821	244	986	294
15°	623	135	817	252
20°	616	116	752	206
25°	555	100	647	166
30°	543	97	646	197
Non-paranoid patients				
−30°	1007	367	1306	597
−25°	1001	383	1295	569
−20°	1245	450	1497	663
−15°	1108	433	1881	664
−10°	1341	538	2465	1424
−5°	1389	612	2262	1327
0°	2317	1606	1740	1013
5°	1663	774	1802	953
10°	1541	712	2245	1251
15°	1127	422	1899	834
20°	1073	397	1649	785
25°	1096	391	1275	566
30°	1015	366	1506	719
Paranoid patients				
−30°	749	277	910	367
−25°	754	306	943	323
−20°	806	279	1100	426
−15°	760	228	1054	427
−10°	993	446	1447	600
−5°	1191	540	1690	798
0°	1977	1169	1286	475
5°	1401	714	1590	664
10°	1022	439	1885	1087
15°	865	355	1201	514
20°	871	264	1183	401
25°	788	295	999	407
30°	698	199	1008	331

patients. Interaction between instructions and orientations was significant, $F(12, 1586) = 10.88$, $p < .0001$. The three-way interaction was not significant.

An analysis of the correlation was computed between gaze directions and haloperidol equivalents for patients. This analysis did not show any influence of medication on reaction time to process orientations in any of the instructions.

4. Discussion

Our hypotheses were that schizophrenic patients would demonstrate a normal capacity to discriminate the direction of others' gaze in a right vs. left judgment task and that the same patients, particularly patients with persecutory delusions, would demonstrate a greater tendency to interpret the direction of others' gaze as looking at them in a self-referred judgment task. The former hypothesis was verified since our results show that patients with schizophrenia were able to discriminate direction of gaze in the right vs. left task. This was assessed by the fact that the angular deviation of gaze detected by both groups of patients was not significantly different from that of controls. Then, the result of our previous experiment (Franck et al., 1998) is confirmed. On the contrary, our data did not confirm the latter hypothesis. Actually, the angular deviations of gaze detected by patients, whether paranoid or not, and by normal controls were not significantly different in the self-referred judgment task.

However, the comparisons between angular discrimination and reaction times in the 2 sessions of the experiment show different profiles in the three samples of subjects. In fact, the sensitivity of the paranoid patients and normal controls to discriminate gaze orientation was significantly different between the 2 sessions. The subjects of both groups were able to discriminate smaller gaze direction differences when they had to determine if the portraits were looking rightward or leftward (around 2° in controls, as well as in patients) than when they had to determine if the portraits were looking at them (5.5° in controls and 5.8° in paranoid patients). The difference between these 2 thresholds was smaller and not statistically significant in non-paranoid patients (2.1° in right vs. left judgment and 4.3° in self vs. non-self judgment). The differences between results in the 2 instructions can be understood as the consequence of the importance of mutual eye contact (Nichols and Champness, 1971). Larger discrimination thresholds in self vs. non-self task could be related to the ability to detect, with certainty, mutual gaze that is fundamental in communication. Response times of patients were globally longer than those of the controls. In both instructions, non-paranoid patients were slower than paranoid patients. Moreover, the 2 samples of patients were slower in self vs. non-self than in right vs. left judgment, while controls took approximately the same time with both instructions.

The fact that the nature of the subject's responses varied little between the three groups of subjects argues not only for a preservation of gaze discrimination mechanisms in schizophrenia, but also for the probable absence of involvement of a gaze discrimination impairment in the genesis of persecutory delusions. Moreover, the present protocol, even in the self-referred judgment task, was probably not able to display experimentally the consequences of persecutory construction. An impairment of EDD's third function (Baron-Cohen, 1995) could explain why paranoid schizophrenic patients report very often that others look at them and interpret others gaze as hostile. The intervention of this third function of EDD is not shown by the nature of responses in the present experiment: paranoid patients did not report more than other subjects the feeling to be looked at in the self-referred judgment (which would have lead to a greater discrimination threshold in these patients than in other subjects). That means that the tasks were not associated with the interpretation of gaze but rather with a perceptual judgment. They both explored elementary gaze direction detection mechanisms of EDD's second function and support the fact that this function is spared.

The abnormal feeling of being stared at, usually experienced in persecutory delusions, appears definitely not to be due to an abnormal low-level analysis of gaze direction. We assume that, it is instead of the consequence of an impairment in a higher level of gaze analysis implying an intentional analysis of gaze. This could be explored with tasks requiring an intentional interpretation of gaze. Baron-Cohen and Cross (1992) have shown that children can

identify mental states of others only on the basis of others' gaze direction. In schizophrenia patients, Kington et al. (2000) demonstrated a reduced ability to recognize complex mental states from eye expressions alone. The authors interpreted these results in terms of impaired theory of mind. We consider that gaze should be studied from this perspective in persecutory delusional patients. The question asked to the patients may arouse their feelings of being looked at (i.e. "Is the other's gaze hostile or not hostile?") and then patients' expectations caused by the instruction would be reinforced by paranoid delusional ideas. Such tasks are currently underway in our laboratory with schizophrenic patients.

The activation of mutual gaze contact in the self vs. non-self judgment could have been responsible for the slowing in patients performing this particular task relative to the other instruction. It is indeed remarkable that only patients presented a difference between the RT of the 2 judgments. This argues against the hypothesis of a general lengthening in patients. Furthermore, treatment cannot be considered as responsible for this fact, since no significant correlation was found between medication and RT. Another explanation is that patients increased their cognitive work consecutive to perception, particularly in the self vs. non-self judgment task. It is possible that patients took more time than controls to give their answers because they exerted more control of their perceptual processes in order to inhibit false interpretations. From this perspective, the lengthened RT should be the consequence of an excessive top-down effect (Fleminger, 1992). The fact that patients were slower in the gaze orientation approaching 0° argues in favor of this explanation. In order to increase their performance they would need to remain particularly attentive to the task, which would be time consuming. The significant differences of RT between patients and controls, particularly in the self vs. non-self judgment, are the only markers of the special attention devoted to mutual gaze by schizophrenic patients. The lengthening of non-paranoid patients relative to paranoid patients could be related to a specific difficulty of this sample to pay attention to other's gaze in the context of social cognition, while paranoid patients show hyperarousal regarding others intentions.

Finally, we raised the question of normalcy of gaze discrimination in schizophrenic patients and particularly paranoid patients. The present experiment confirms that low-level processes related to perception of gaze are unimpaired in schizophrenia and revealed unable to explore the higher level of interpreting others gaze. Further studies are necessary to specifically explore this level.

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References

Anderson, J.R., 1980. Cognitive Psychology and its Implications. WH Freeman, San Francisco.

Andreasen, N.C., 1983. The Scale for Assessment of Negative Symptoms (SANS). The University of Iowa, Iowa City, IA.

Andreasen, N.C., 1984. The Scale for Assessment of Positive Symptoms (SAPS). The University of Iowa, Iowa City, IA.

Anstis, S.M., Mayhew, J.W., Morley, T., 1969. The perception of where a face or television portrait is looking. Am. J. Psychol. 82, 474–489.

Baron-Cohen, S., 1995. Mindblindness. MIT Press, Cambridge, Ma.

Baron-Cohen, S., Cross, P., 1992. Reading the eyes: Evidence for the role of perception in the development of a theory of mind. Mind Language 6, 173–186.

Campbell, R., Heywood, C.A., Cowey, A., Regard, M., Landis, T., 1990. Sensitivity to eye gaze in prosopagnosic patients and monkeys with superior temporal sulcus ablation. Neuropsychologia 28, 1123–1142.

Conrad, K., 1958. Die beginnende Schizophrenie. Versuch einer Gestaltanalyse des Wahns. Thieme, Stuttgart.

Fechner, G.T., 1860. Elemente der Psychophysik. Breitkopf und Hätel, Leipzig.

Fleminger, S., 1992. Seeing is Believing: The role of Preconscious Perceptual Processing in Delusional Misidentification. Br. J. Psychiatry 160, 293–303.

Franck, N., Daprati, E., Michel, F., Saoud, M., Daléry, J., Marie-Cardine, M., Georgieff, N., 1998. Gaze discrimination is unimpaired in schizophrenia. Psychiatry Res. 81, 67–75.

Gesheider, G.A., 1976. Psychophysics: Method and Theory. Lawrence Erlbaum Associates, Hillsdale, NJ.

Gur, R.E., Pearlson, G.D., 1993. Neuroimaging in schizophrenia research. Schizophr. Bull. 19, 337–353.

Kington, J.M., Jones, L.A., Watt, A.A., Hopkin, E.J., Williams, J., 2000. Impaired eye expression recognition in schizophrenia. J. Psychiatry Res. 34, 341–347.

Lecrubier, Y., Sheehan, D., Weiller, E., Amorin, P., Bonora, I., Harnett Sheehan, K., Janvas, J., Dunbar, J., 1997. The MINI International neuropsychiatric interview (MINI) a short diagnostic structured interview: reliability and validity according to the CIDI. Eur. Psychiatry 12, 217–224.

McCarley, R.W., Shenton, M.E., O'Donnell, B.F., Faux, S.F., Kikinis, R., Nestor, P.G., Jolesz, F.A., 1993. Auditory P300 abnormalities and left posterior superior temporal gyrus volume reduction in schizophrenia. Arch. Gen. Psychiatry 50, 190–197.

Nichols, K., Champness, B., 1971. Eye gaze and the GSR. J. Expl. Social Psychol. 7, 623–626.

Oldfield, R.C., 1971. The assessment and analysis of handedness. Neuropsychologia 9, 97–113.

Perrett, Mistlin, Chitty, Harries, Newscombe, de Haan, 1988. Neuronal mechanisms of face prception and their pathology. In: Kennard, C., Clifford Rose, F. (Eds.), Physiological Aspects of Clinical Neuro-ophtalmology. Chapman and Hall, London, pp. 137–154.

Riddoch, M.J., Humphreys, G.W., 1993. BORB: Birmingham Object Recognition Battery. Lawrence Erlbaum Associates, Hove.

Rosse, R.B., Kendrick, K., Wyatt, R.J., Isaac, A., Deutsch, S.I., 1994. Gaze Discrimination in Patients With Schizophrenia: Preliminary Report. Am. J. Psychiatry 151, 919–921.

Spitzer, M., 1990. On defining delusions. Compr. Psychiatry 31, 377–397.

Tiberghien, G., 1984. Initiation à la Psychophysique. Presses Universitaires de France, Paris.

Wicker, B., Michel, F., Henaff, M.-A., Decety, J., 1998. Brain regions involved in the perception of gaze: a PET study. Neuroimage 8, 221–227.

Zipursky, R.B., Marsh, L., Lim, K.O., DeMent, S., Shear, P.K., Sullivan, E.V., Murphy, G.M., Csernansky, J.G., Pfefferbaum, A., 1994. Volumetric MRI assessment of temporal lobe structures in schizophrenia. Biol. Psychiatry 35, 501–516.