



The relationship between visual-perception and attention in Chinese with schizophrenia

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Abstract

Previous studies suggest possible visual-perceptual deficits associated with schizophrenia, and co-existing impairments in attention and visual-perceptual function in people with schizophrenia. This study examines if people with schizophrenia show visual-perceptual difficulty and whether different components of attention, namely sustained attention, selective attention, switching attention and attentional control processing, relate to the visual-perceptual function of people with schizophrenia differently. A total of 94 participants voluntarily participated in this study: 47 of them were diagnosed with schizophrenia and 47 were normal controls. Visual-perceptual abilities were measured by the Hooper Visual Organization Test (HVOT) for visual organization ability and the Judgment of Line Orientation Test (JLOT) for spatial perception and orientation. Tests for measuring different components of attention were also administered. We observed that our clinical participants performed significantly poorer in both the HVOT and the JLOT. We further noticed that nonverbal intelligence had a significant influence on our participants' performance in these two administered tests. Regarding the relationship between attention and visual-perceptual function, our findings indicated that such a relationship existed only among our clinical participants, not the normal controls. The attention control process significantly predicted the performance in the HVOT and switching attention efficiency significantly predicted the performance in the JLOT.

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Patients with schizophrenia exhibit pervasive neuropsychological deficits (Blanchard and Neale, 1994; Heinrichs and Zakzanis, 1998; Riley et al., 2000), in which impairment in visual-perceptual function is common (Chey and Holzman, 1997; Place and Gilmore, 1980; Silverstein et al., 1996; Wells and Lev-

enthal, 1984). Visual-perceptual function is a broad concept including spatial function (perception, estimation and orientation), visual function (construction, organization and recognition), closure and color estimation and discrimination. Such impairments could have considerable negative impacts on schizophrenic patients' general cognitive functioning because intact visual-perceptual function is the foundation of normal processing and organization of the enormous inputs from the visual world. Furthermore, according to Silverstein et al. (1996, 1998a,b), visual-perceptual

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organization is a prerequisite for rapidly accessing semantic memory. Dysfunction of the ability to generate representations of segmented visual information could lead to reduced integration of visual stimuli with relevant stored memory.

Physiologically, Schechter et al. (2003) reported a significant impairment in the function of the magnocellular, but not parvocellular pathway, in people with schizophrenia. Neuropsychologically, Stuss et al. (1984) administered visual-perceptual and visual-constructional tests to leucotomized schizophrenic patients, nonleucotomized schizophrenic patients, and healthy controls. No significant differences were found among the three groups in the subjects' ability to copy simple figures, though the schizophrenic patients showed visual-spatial deficits in complex tasks. Riley et al. (2000) examined the spatial ability of schizophrenic patients with first-episode psychosis and of healthy controls using Benton's Judgment of Line Orientation (Benton et al., 1983). There was no significant difference in spatial-perceptual ability between the two groups.

Yurgelun-Todd et al. (1987), on the other hand, found that schizophrenic and bipolar patients displayed visual-spatial deficits in the copying task of the Rey Osterrieth Complex Figure (Osterrieth, 1994). Joobar et al. (2002) examined the visual-spatial abilities of neuroleptic-responder schizophrenic patients, neuroleptic-nonresponder schizophrenic patients and healthy volunteers using the Wechsler Adult Intelligence Scale-Revised (Wechsler, 1981). Both the former two groups showed poorer visual-spatial ability than the healthy controls, suggesting that perceptual deficits could be a state marker for schizophrenia.

To understand the nature of visual-perceptual function as experienced by people with schizophrenia, knowledge of perceptual organization and attention, and their interrelations is needed. Deficits in attention have been identified as core deficits of schizophrenia since Kraepelin in 1919. Recent studies have suggested that there are several distinct components of attention (Allen et al., 1997; Kremen et al., 1994). Four commonly identified components are sustained attention, selective attention, switching attention and attentional control processing (Mirsky et al., 1991; Posner and Peterson, 1990; Stuss and Benson, 1986; Zubin, 1975).

The serial two-stage model sheds light on the interrelationship between perceptual organization and attention. According to this model, perceptual organization is an early information process that occurs prior to attentional distribution (Kahneman, 1973; Kahneman and Henik, 1981; Kahneman and Treisman, 1984). Recurrent processing occurs before the features of an object are attentively grouped and the stimulus can enter consciousness (Lamme and Roelfsema, 2000). An initial global analysis occurs preattentively in which stimulus components are broadly analyzed and grouped into subareas. Following this is a stage of serial analytic processing where attentional resources are allocated for processing the most relevant stimulus to the perceiver. Based on this model, the perceptual organization deficit hypothesis was developed, which proposes that patients with schizophrenia have an impaired ability to group stimulus components into object representations on the basis of Gestalt principles (Cox and Leventhal, 1978; Knight, 1992; Place and Gilmore, 1980; Wells and Leventhal, 1984). Such impairments may therefore subsequently lead to poor figural configuration of visual stimuli, an increased competition for attentional resources, poorly defined foci of attention and rapid shifting of attention between stimuli, or slowness in processing relevant visual stimuli (Silverstein et al., 1996). Although other studies showed an interaction between the global and serial processes (e.g. Rock et al., 1992), the findings continue to suggest an interrelation of some form between attention and perceptual organization that eventually has an impact upon visual perception.

This study sought to verify if people with schizophrenia showed visual-perceptual difficulty. Furthermore, despite the well-established findings showing impairments in attention and perceptual organization among patients with schizophrenia (Buchanan et al., 1997; Joobar et al., 2002; Mohamed et al., 1999; Riley et al., 2000; Smith et al., 1998), there is a paucity of research devoted to understand the interrelationship between attention and visual-perceptual organization. We therefore speculated that visual organization, and spatial perception and orientation of people with schizophrenia would be predicted by different components of attention, namely sustained attention, selective attention, switching attention and attentional control processing.

1. Methods

1.1. Participants

A total of 94 individuals participated in the present study: 47 belonged to the clinical group and 47 to the normal control group. All the participants gave their written informed consent prior to participation. The demographic and clinical characteristics of the clinical and normal populations are presented in Table 1.

The two groups were matched in terms of gender composition (21 men and 26 women in each group, $\chi^2(df=1)$, $p < 0.01$, ns). However, we could not match the two groups in both the dimensions of age and education. When we matched in terms of education [$F(1,92) = 0.12$, $p = 0.73$], the two groups were different in terms of age [$F(1,92) = 163.35$, $p < 0.01$]. The normal controls would be of a much higher level of education if they were matched to the clinical population in terms of age. Given that both age and education bear a strong relationship to intellectual ability (Lezak, 1995), in order not to confound our findings due to the inclusion of too many variables, we decided to use the scores in the Test of Nonverbal Intelligence-3 (TONI-3; Brown et al., 1997) for the two groups [$F(1,92) = 55.17$, $p < 0.01$], which estimates nonverbal intellectual ability, in further data analysis in this study. As depression has a significant

impact on cognitive function (Lezak, 1995), we used the Beck Depression Inventory-II (BDI; Beck et al., 1996) to ascertain the degree of depression felt by our participants. The two groups had significantly different scores in the BDI [$F(1,92) = 78.770$, $p < 0.01$].

1.1.1. Clinical group

Forty-seven schizophrenic patients with well-regulated symptoms were recruited from an outpatient clinic in a public hospital in Hong Kong. These schizophrenic patients underwent a clinical interview as part of a comprehensive medical screening by an experienced mental health professional. The patients had to meet the Diagnostic and Statistical Manual of Mental Disorders-IV Test Revised (DSM-IV-TR; American Psychiatric Association, 2000) criteria for schizophrenia in order to be included. Patients with organic brain disorder, a history of severe head trauma, or a significant history of drug abuse or alcoholism were excluded from the study.

The mean duration of illness was 9.01 (S.D. = 7.68) years and the average age of onset of illness was 28.74 (S.D. = 8.40) years. The mean number of hospitalizations was 1.85 (S.D. = 1.38). The severity of the clinical syndrome at the time of examination was assessed using the Scale for Assessment of Negative Symptoms (SANS; Andreasen, 1982) and the Scale for Assessment of Positive Symptoms (SAPS; Andreasen, 1984). All the patients were on antipsychotic medication at the time of the study. We did not control for patient medication because those patients who agreed to be withdrawn from their medication were not representative of the clinical population being studied (Silverstein et al., 1996; Spohn and Fitzpatrick, 1980). Though visual-perceptual function among patients with schizophrenia seems to be responsive to drug treatment (e.g. Purdon et al., 2000), Killan et al. (1984) concluded in their study that psychotropic medication and the regime of its administration did not affect performance in cognitive and perceptual tests for schizophrenic patients in any specific manner. Joobar et al. (2002) studied the neuropsychological profile of patients with schizophrenia. Neuroleptic responder and neuroleptic-nonresponder patients, representing the two extremes of the neuroleptic response spectrum, were examined and compared with healthy controls. Although they performed

Table 1
Demographic and clinical characteristics of patients with schizophrenia and normal controls

Variable	Patients (n=47)		Controls (n=47)		F	p
	M	S.D.	M	S.D.		
Nonverbal IQ (TONI-3)	22.77	5.90	30.06	3.25	55.167	<0.001
Years of education	11.24	3.24	11.19	2.36	0.123	0.726
Age (years)	37.83	9.36	62.85	9.62	163.35	<0.001
BDI	5.66	3.13	1.43	0.95	78.77	<0.001
Age of onset (years)	28.74	8.40	NA			
Illness duration	9.01	7.68	NA			
SAPS	4.47	5.90	NA			
SANS	7.11	8.04	NA			
No. of admissions	1.85	1.38	NA			

TONI-3 = Test of Nonverbal Intelligence-3, BDI = Beck Depression Inventory, NA = not applicable, SAPS = Scale for Assessment of Positive Symptoms, SANS = Scale for Assessment of Negative Symptoms.

significantly below the level of the normal subjects, the two groups did not differ from each other in terms of visual-spatial ability.

1.1.2. Normal control group

Forty-seven controls engaged in full-time employment, matched for education level (in years), were recruited. Controls with a previous history of psychiatric illness, or drug or alcohol dependence were excluded. All the participants were administered the Test of Nonverbal Intelligence to assess their current intellectual functioning, and the BDI to detect signs and symptoms of depression.

1.2. Instruments

All the participants completed a comprehensive battery of neuropsychological tests selected to assess intelligence, selective attention, sustained attention, auditory attention span, switching attention, the attention control process, visual-perceptual organization ability and visual-spatial perception ability. The tests were administered and scored by trained research assistants who were undergraduate students majoring in psychology or psychology graduates. The battery of tests was administered within 7 days of rating the symptoms.

1.2.1. Digit Vigilance Test (DVT; Lewis and Kupke, 1977)

The DVT, which is a subtest of the Lafayette Clinic Repeatable Cognitive Perceptual-Motor Battery, was used to assess sustained attention.

1.2.2. Stroop Test (Stroop, 1935)

The Stroop Test has been a common measure of selective attention (e.g. Amador et al., 1998). A previously validated Chinese translation of the Victoria Version of this test was used in the present study (Lee and Chan, 2000).

1.2.3. Symbol Digit Modalities Test (SDMT; Smith, 1982)

SDMT is a measure of switching attention. Following the standard administration procedure, both the written and the oral formats of the test were administered (Brouwer and Zomeran, 1994; Lezak, 1995). However, only the score of the oral format was

used as a measure of the switching attention in the present study. This decision was based on the findings of Ponsford and Kinsella (1992) which suggested that the oral format of the SDMT was a better measure for switching attention.

1.2.4. Color Trails Test (CTT; D'Elia and Satz, 1989)

The CTT is an analogue of the Trials Making Test (TMT) from the Halstead-Reitan Battery in which letters from the English alphabet are substituted with colors (Cohen, 1993; D'Elia et al., 1996). Attentional control processing was assessed by the CTT (D'Elia et al., 1996).

1.2.5. Judgment of Line Orientation Test (JLOT; Benton et al., 1983)

The JLOT was used as a test of spatial perception and orientation. It consists of 5 practice and 30 test items. Each item comprises a pair of lines printed on one page. The subject is required to match the spatial orientation of these pair of lines with the corresponding ones from an array of lines shown on the previous page.

1.2.6. Hooper Visual Organization Test (HVOT; Hooper, 1983)

The HVOT, on the other hand, was used as a test of visual-perceptual organization. It consists of 30 drawings of common objects cut into several parts randomly displayed. The subject is required to conceptually rearrange the parts and name the objects.

1.3. Procedure

Each subject was administered the tests in a standardized order, on a one-on-one basis. Sustained attention was measured at the beginning of the testing.

Testing was limited to 1 h and was conducted in a quiet room provided by the hospital.

1.4. Statistical analysis

The hypothesis of group difference in visual-perceptual function was tested by the analysis of covariance (ANCOVA), with visual-perceptual measurements as dependent variables and the scores in the TONI-3 and the BDI as the covariates. The hypothesis of the differential pattern of relationships between the

different components of attention and visual-perceptual function was examined by multiple regression. All statistical tests were carried out using the Statistical Package for the Social Sciences (SPSS). The level of significance was set at $\alpha=0.05$.

2. Results

The scores of the schizophrenic patients and the healthy controls in the neuropsychological tests are displayed in Table 2.

To test hypothesis 1, that people with schizophrenia would show visual-perceptual difficulty, ANCOVA tests were conducted to determine the between group differences in the HVOT and the JLOT, with the scores in the TONI-3 and the BDI as covariates. The results indicated significant group differences in the HVOT [$F(1,90)=6.13, p=0.015$] and the JLOT [$F(1,90)=29.865, p<0.01$]. These findings supported our speculation that people with schizophrenia did suffer from visual-perceptual deficits as measured by the HVOT and the JLOT. The score in the TONI-3, though not in the BDI, was a significant covariate ($p=0.001$ and <0.001 for the HVOT and the JLOT, respectively), implying that ability measured by the TONI-3 has a significant influence on the performance in both the HVOT and the JLOT.

To test hypothesis 2, that different components of attention, namely sustained attention, selective attention, switching attention and attentional control pro-

Table 2
Comparisons of neuropsychological test scores among patients with schizophrenia and healthy controls

Measures	Patients ($n=47$)		Controls ($n=47$)	
	<i>M</i>	S.D.	<i>M</i>	S.D.
DVT-Total Time	499.30	208.98	309.49	12.50
Stroop Test (I)	14.89	8.87	5.28	0.91
CTT (I)	58.28	45.93	36.58	7.30
SDMT-Oral	47.53	12.82	66.70	2.79
HVOT	19.30	4.74	22.68	1.51
JLOT	17.81	6.36	26.79	1.23

DST = Digit Span Test (Forward), SDMT = Symbol Digit Modality Test, Stroop Test (I) = Interference score, CTT (I) = Color Trails Test Interference Score, DVT = Digit Vigilance Test, HVOT = Hooper Visual Organization Test, JLOT = Judgment of Line Orientation Test.

Table 3
Summary of stepwise regression analysis for variables predicting the HVOT

Predictors	<i>B</i>	S.E.	β	R^2
Constant	11.454	2.428		
SDMT-Oral	0.165**	0.049	0.446	0.199
Excluded variables				
DVT-Total Time			0.263	
Stroop Test (I)			-0.115	
CTT (I)			-0.040	

** $p<0.01$.

cessing, would relate to the visual-perceptual function of people with schizophrenia differently, step-wise multiple linear regression procedures were employed. The scores in the HVOT and the JLOT were used as the criterion variables. Tables 3 and 4 provide a summary of these results.

Four variables, including the scores in the DVT (total time), the Stroop Test (interference score), the SDMT (oral version) and the CTT (interference score), were entered as predictor variables using the stepwise method. Among the normal controls, none of the four variables significantly predicted the performance in the HVOT or the JLOT ($p>0.05$). However, consistent with our speculation, different components of attention related to the performance in the HVOT and the JLOT of our clinical participants. For the HVOT, only the SDMT (oral version) significantly predicted its score ($p=0.002$), which explained 19.9% of the variance of the score in the HVOT. The other variables were not significant predictors ($p>0.05$). For the JLOT, the CTT (interference score) was the only significant predictor of performance ($p=0.002$), explaining 18.9% of the variance of the score in the JLOT.

Table 4
Summary of stepwise regression analysis for variables predicting the JLOT

Predictors	<i>B</i>	S.E.	β	R^2
Constant	7.80	3.474		
CTT (I)	-6.017E-02**	0.019	-0.434	0.189
Excluded variables				
DVT-Total Time			-0.129	
Stroop Test (I)			0.100	
SDMT-Oral			0.222	

** $p<0.01$.

3. Discussion

This study examined visual-perceptual function of people with schizophrenia and how different components of attention related to it. The findings indicated that people with schizophrenia did suffer from visual-perceptual deficits in the areas of visual-perceptual organization (measured by the HVOT), and spatial-perceptual organization and orientation (measured by the JLOT). We also observed that different components of attention related to the visual-spatial function of people with schizophrenia differently. Attentional control processing, measured by the CTT, turned out to be the best predictor of performance in the HVOT, while switching attention, measured by the SDMT, was the best predictor of performance in the JLOT. A relationship between attention and visual-perceptual function was not observed for our normal controls.

3.1. *Visual-perceptual function*

Our findings are consistent with those of previous studies (Buchanan et al., 1997; Jooper et al., 2002; Purdon et al., 2000; Schuepbach et al., 2002; Stuss et al., 1984; Zakzanis et al., 2001). Using a task of reporting displayed lines, Place and Gilmore (1980) demonstrated that perceptual deficits in schizophrenic patients were due to a failure to organize information at an early stage of visual processing. Wells and Leventhal (1984) replicated the study with several methodological refinements, and confirmed the findings.

However, our findings contradict those of other reports. Faustman et al. (2001) evaluated the basic perceptual and visual processes in patients with schizophrenia and observed that most of the patients showed a normal range of performance in neuropsychological tests including the Right-Left Orientation Test, the JLOT and the Visual Form Discrimination Test. Also, Riley et al. (2000) found that there were no significant differences in performance in the JLOT between patients with first-episode psychosis and controls in terms of visual-spatial perception.

The discrepancy in the findings could be explained by methodological heterogeneity across studies. In our study, we included only chronic patients diagnosed with schizophrenia, whereas in some other studies, a broader spectrum of clinical participants may have been recruited (e.g. Riley et al., 2000). The

degree of chronicity of the clinical participants may also affect the findings regarding the visual-perceptual function of patients with schizophrenia. For example, Riley et al. (2000) used patients with first-episode psychosis, whereas our participants had reached a more chronic stage of their illness. Sweeney et al. (1991) conducted a longitudinal study on the stability of neuropsychological deficits in schizophrenic patients, and observed significant improvement in their scores in the JLOT after 1 year (Benton et al., 1983). The discrepancy in the symptom constellation of the participants may have contributed to the variation in the research findings. Faustman et al. (2001) suggest that negative symptoms may relate to visual-perceptual function, and that the differences in the sample combination could interfere with the findings regarding the visual-perceptual function of patients with schizophrenia.

Though the JLOT and the HVOT are commonly used in evaluating the visual-perceptual function of patients with schizophrenia, the batteries of tests adopted have varied slightly across studies. Some used block design and picture completion subtests of the Wechsler Scale (e.g. Jooper et al., 2002), while others used different measures of visual-perceptual function (e.g. Faustman et al., 2001). Cross-study comparisons would be more meaningful and powerful if researchers were to adopt a more unified experimental protocol.

We observed that nonverbal reasoning estimated by the TONI-3 had a significant influence on the visual-perceptual performance of our clinical participants. Future studies should attempt to consider the impact of this variable on the validity of conclusions about the visual-perceptual function of people with schizophrenia.

3.2. *Attention and visual-spatial function*

Our findings are consistent with those of previous reports that attention and the visual-spatial function of people with schizophrenia are related. For example, Tek et al. (2002) evaluated the integrity of the perceptual system for object and spatial visual information, and the relevant working memory system after adjusting for individual perceptual performance differences. They concluded that the systems governing object and spatial visual perception, and working memory appeared to be affected differently by schizophrenia.

We observed that the attention control process is a significant predictor of visual-perceptual organization measured by the HVOT. We therefore speculated that an inability to focus on relevant stimuli and disregard irrelevant stimuli may overload the limited amount of processing capacity available (Kahneman, 1973). Furthermore, impairments in the activation and allocation of attention (Nestor et al., 1990) create further difficulty for the attention control process that may eventually affect visual-perceptual organization. On the other hand, switching attention measured by the SDMT predicts spatial perception and orientation measured by the JLOT. Considering the findings of Gold et al. (2002) that performance in the Digit-Symbol Test, a variant form of the SDMT, was also a significant predictor of functional outcomes, in terms of length of job tenure, it further suggests that spatial perception and orientation may bear an impact on the level of functioning of people with schizophrenia in the real world.

Given the fact that both attentional tasks, namely the CTT and the SDMT, predicting visual organization and orientation are timed tasks, could a generalized slowing of neurocognitive functions in people with schizophrenia limit the amount of relevant information that can be processed within a limited time frame (Levin et al., 1989) and henceforth affect visual-perceptual functioning observed in people with schizophrenia? This speculation awaits verification in future research employing attentional paradigms that are not timed.

Chey and Holzman (1997) observed that people with schizophrenia outperformed controls on tasks that required the organization of complex figures into similar parts, the performance of which relies very much on the ability to follow Gestalt principles. Developmental studies have found supporting evidence that the ability to follow Gestalt principles appears in the early stages of cognitive development and requires little experience (Bornstein et al., 1981; Ghim, 1990; Van Giffen and Haith, 1984). Thus, Gestalt perception is automatic in nature and puts less demand on attentional resources. Could it be that automatization of gestalt perception in people with schizophrenia may be less well developed or even impaired when compared with the normal controls; therefore, Gestalt perception would imply a much heavier demand on attentional resources for people

with schizophrenia, and thus leading to the impaired visual-perceptual function in them observed in this study? This is a question worth addressing in future research.

In summary, the findings of this study clearly indicate that visual-perceptual deficits do exist in patients with schizophrenia, which may extend beyond the domains measured in this study. Also, different attention components relate to the visual-spatial function among people with schizophrenia differently. The unique patterns of such relationships imply that different models are needed to describe specific domains of visual-spatial function and attention. Furthermore, future research efforts to understand the universality of the pattern of visual-spatial deficits across the different subgroups of schizophrenia will provide theoretical refinement of the cognitive impact of schizophrenia.

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