

Visual Impairment Affects the Perception of Reality: Visual Processing Deficits among Adolescents with Schizophrenia

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Abstract

Background: One important diagnostic characteristic of schizophrenia is reality-testing impairment. Since the disease usually breaks out during adolescence, we hypothesized that visual processes that normally develop during adolescence will be affected in schizophrenic adolescents.

Method: To test this hypothesis, we tested object naming and mental rotation performance in adolescents with schizophrenia and contrasted it with the performance of two control groups of healthy adolescents and young adults. To further examine the differences during development, we compared the standard performance scores of the three research groups.

Results: Comparing the adolescent patients with healthy participants of the same age, we obtained significant difference of functioning in both tests. Moreover, Performance was lower as the disease broke out at an earlier age.

Conclusion: The significant correlation between the age of onset of schizophrenia with severity of perceptual damage suggests that the onset of schizophrenia halts the normal development of the visual system. One limitation of the study is the difficulty to test whether the defects are due to the onset of the disease or innate cognitive deficits. Another limitation in this study is scarcity of patients is, but the significant statistical results cover up the theoretical association with reality testing, which is discussed.

Keywords: Adolescence; Visual-perception; Development; Schizophrenia-outbreak; Reality-testing

Introduction

Cognitive deficits are one of the core features of schizophrenia, and affects on the patients' daily functioning. Research has provided evidence for a wide variety of cognitive dysfunctions in areas such as attention, memory, language, executive functions and visual perception [1-4]. However, although individuals with schizophrenia are known to suffer from various cognitive difficulties, one of the important diagnostic characteristic of these patients is reality testing impairment, which can be related to poor perceptual processing (e.g. Stern, Caligor, Clarkin,... & Kernberg). Within the domain of visual perception, studies have shown that adults with schizophrenia perform poorly on visual tasks, especially on tasks requiring high-level processing [5,6]. This high level of processing involves two main mechanisms: the spatial information processing (dorsal stream) and the object information processing (ventral stream) [7]. Even though there is consistency with higher visual processing disability, studies show that adult patient with schizophrenia display more deficits in object and form perception than in spatial perception [8,9].

The visual system allows objects to be recognized even when there is missing visual information. For example when the object is obstructed or only partially in the field of view, or when there are fragmented changes in their spatial properties. The ability to recognize common objects when they are shown from an unusual viewpoint involves executive and top-down processes [10] and may require the use of mental manipulations, such as 'mental rotation'. Mental rotation is the spatial ability which enables the individual to both transform visual images and to use images of common objects stored in the

short-term memory [11]. Some theorists of visual object recognition believe that mental rotation is integral to the recognition process [12] while others assert that object recognition is not based on a continuous alteration process, such as mental rotation. For example, [13] have suggested that in order to recognize an object, people compare it with mentally stored representations, which may or may not exist. If the object is recognized, it means that information is drawn from semantic memory, including the production of its name [14] have proposed a model in which the recognition process relies on the accumulation of evidence in populations of viewpoint-specific neurons.

The majority of cognitive deficits found in adult patients with schizophrenia have also been demonstrated in children and adolescents with schizophrenia [15,16]. This may have numerous implications for the ability of schizophrenics to acquire new skills. From a neurodevelopmental point of view, cognitive functions and processes undergo substantial development throughout childhood and adolescence [17,18]. For instance, Casey, Giedd and Thomas found that memory and attention continue to develop throughout childhood and adolescence. Mental rotation ability was found to be acquired at approximately age seven and to continue developing far beyond that age [19,20,21]. Kail, Pellegrino and Carter suggested that the basic processes of information manipulation become automatized with age and that this shows itself in quicker reaction times. The question that arises with respect to patients with schizophrenia is whether they can achieve normal cognitive maturation or whether their cognitive impairment worsens over the course of adolescence.

There is a relative paucity of studies assessing adolescents with schizophrenia. In the present study we tested object naming and mental rotation performance in adolescents with schizophrenia and contrasted it with the performance of two healthy control groups, adolescents and young adults. The addition of the healthy young

adults group (aged 21-30) was to allow a reference for ripe normal functions and perceptual abilities. We hypothesized that the visual processes that develop during adolescence will be damaged in schizophrenic adolescent patients, while these same processes will continue to develop normally in healthy adolescents. These results shed light on the possibility that damage to normal development of the visual system, is connected with the outbreak of the disease and in reality testing symptom.

Materials and Methods

Subjects: Eighty-one subject were participated the study. Thirty-five adolescent subjects (aged 12-20) and forty-six healthy young adults

(aged 21-30). Fifteen participants (10 males, 5 females) were schizophrenic outpatients from Gehha Psychiatric Hospital in Israel, who had been diagnosed by a specialist psychiatrist according to the DSM-IV via clinical interview (Table 1); twenty healthy adolescent controls (14 males, 6 females) and forty eight healthy young adults (19 males, 27 females). Patients were all receiving new version antipsychotic medication and were clinically at stable state and without psychotic symptoms. There was no medication uniformity of the participants with schizophrenia, not with the type of medication and nor with concentrations. Among the healthy groups, mental and neurological illnesses were ruled out according to self-reports. Young healthy subjects were recruited using the "snowball" and the older subjects were all undergraduate students at the University of Ariel.

Patient	Gender	Age	Education	Diagnostic subtype	Illness duration	Attention deficit
1.	F	12	6	NP	2.5	"no"
2.	M	13	7	NP	1	"no"
3.	F	16	11	P	2	"no"
4.	M	16	10	NP	2	"yes"
5.	M	16	8	P	5	"yes"
6.	M	17	11	NP	6	"no"
7.	F	17	7	NP	5	"no"
8.	M	18	11	P	2	"no"
9.	M	18	12	NP	6.5	"no"
10.	M	18	11	P	8.5	"no"
11.	M	19	11	P	1.5	"no"
12.	M	20	8	P	2.5	"yes"
13.	F	20	10	P	2	"no"
14.	M	20	12	P	5	"no"
15.	F	20	12	NP	8.5	"no"

Table 1: Patient Characteristics Diagnostic subtype: P/NP=paranoid/non-paranoid symptoms. Illness duration=Years from first episode diagnosis. Attention deficit=ADD additional diagnosis.

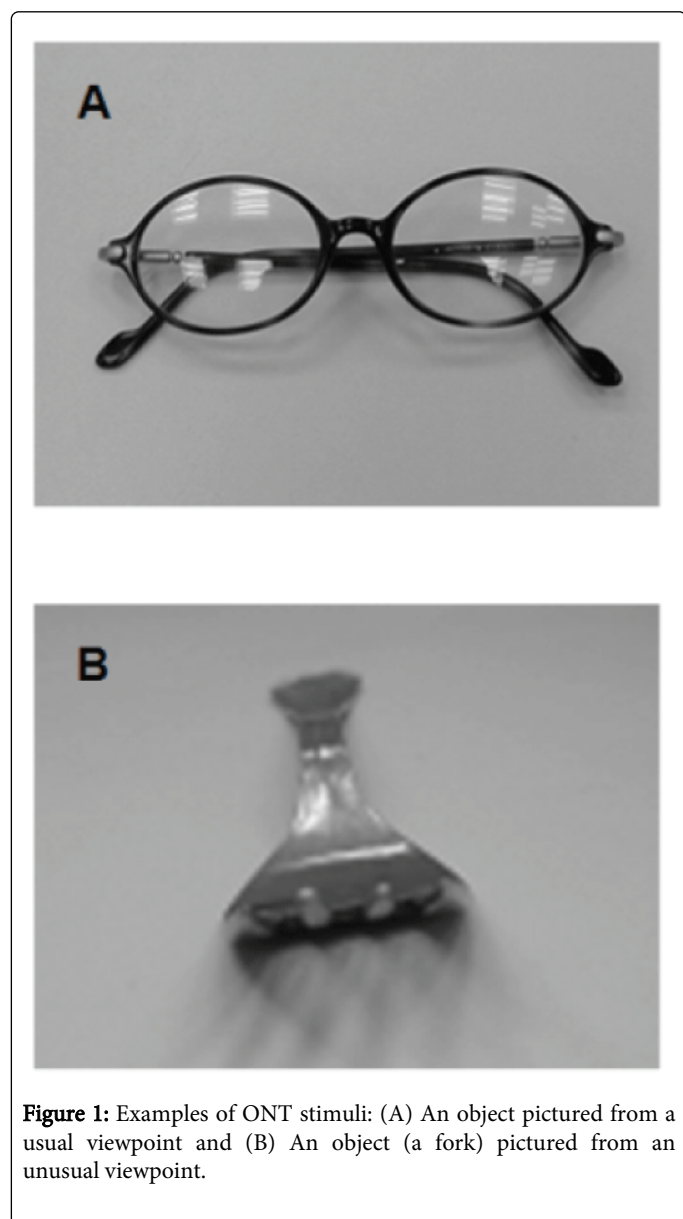
Materials

There cognitive tests were used: the first one was the Hebrew version of the General Information (G.inf) subtest from the Wechsler Adult Intelligence Scale (WAIS) [22]. The WAIS is a widely used battery of tests designed to measure intelligence in adults and adolescents that are validated in many languages (including Hebrew). The G.inf test includes 29 questions addressing a broad range of general knowledge topics. This subtest measures the ability to acquire, retain, and retrieve general information.

The other two tests were computerized, and the stimuli generated by the Super-Lab software (version 4.2). Object Naming test (ONT) [23]: Stimuli consisted of 40 black and white pictures of common objects. Twenty objects were pictured from a usual viewpoint, and 20 different objects were pictured from an unusual point of view. The test session included two different naming conditions, usual and unusual, presented in a block-design fashion. Four different blocks were constructed, and each condition- block was presented in alternating order during the session. Ten epochs were presented in one block, and

each of them included an experimental stimulus followed by a picture of a centered fixation point on a gray background, presented for 550 ms and 1,550 ms, respectively. The blocks were separated by intervals, during which participants viewed a gray background (i.e., blank condition). During this time, the subjects had to press the space-bar as soon as they identified the object and say his name out loud. Is recorded and the response time of the subjects' answers. Mental Rotation test (MRT): The test consisted of forty 2D pairs of abstract stimuli presented in two different conditions: same/different; rotated/mirrored. Each condition includes 20 pairs of stimuli presented simultaneously and side by side. In Same/Different (MR1) condition, minimal difference between each pair of stimuli and the subject is asked to identify whether a pair is identical or different. The Rotated/Mirrored (MR2) condition provide pairs of identical stimuli, but are shifted (rotated) relative to each other. Half of pairs rotated (mirrored) relative to each other. Subjects are asked to mentally rotate clockwise the right-sided stimulus, until he/she can judge if it is the same or

mirrored compared to the left stimulus. Stimuli continue to be displayed until pressing a decision. Response and RT were recorded.



Procedure

All subjects were given an explanation of the study, signed an informed consent form approved by the Institutional Ethics Committee. For subjects who were under the age of 18, we received approval and signature of the guardian (parent).

About the adult subjects, they only dealt with computerized tests, while the adolescent participants also met up G.inf questionnaire test before making a computerized version of the test. All subjects got widely detailed explanation about the computerized tasks and stimuli, and were also given examples, and all had practice prior to testing. Each participant underwent the procedure in front of the examiner, who was in the room with the participant during the test.

Data analysis

Accuracy and RT analyzed, using SPSS17 software. Number of noteworthy comments regarding data processing: (I). Since adolescent groups were relatively small (less than 30), we used the Mann-Whitney-U non-parametric test, which is more stringent test relatively to the T test. (II). In order to compare the performance of different tests (ONT and MR) standard scores (Z-scores) were calculated for each subject, and we compare averages of Z-scores. (III). Variance is represented by the Standard Error of Mean (SEM).

Results

No demographic differences were obtained between the two adolescent groups (Table 2). In ONT, the performance in usual condition was almost identical and high in two healthy groups, while patients performed much worse ($F(2, 80)=18.7, p=0.0001$). By contrast, unusual condition was difficult for all participants, and both adolescent groups (healthy and schizophrenic) performed poorer than the healthy young adults ($F(2, 80)=20.0, p=0.0001$). A significant difference was also be provided for the MR condition, but it was minor ($F(2,80)=3.6, p=0.03$; Table 3 and 4).

A relationship between the development of the disease and the cognitive functioning was measured by correlating performance with age. Significant correlation was found between patients age and MR2 test performance ($R_p=-0.63; p=0.01$). There was no such association in the two healthy groups. Furthermore, the age of onset of schizophrenia was associated with the patients' performance in the unusual condition (in earlier onset, functioning was worse; Figure 2).

	Controls	Patients	Mann-Whitney (Z)	P
Age	16.80 (0.37)	17.33 (0.64)	1.638	>0.05
Education	10.43 (0.28)	9.80 (0.53)	0.549	>0.05

Table 2: Age and Education (mean and SEM) of the Two Adolescent Groups

According to Z-scores (Figure 3), mean patients' functioning in ONT is with more than two standard-deviations (SD) worse in respect with normal's, while their dysfunction in MR test is about 1SD below average. In addition, although the cognitive functioning of the usual condition has completed development before normal puberty (the same function in two groups of healthy), the functioning of the

unusual condition and MR continue to evolve. There were no significant differences in response times (Table 4). Moreover, although patient performed poorer in G.inf, (8.5 ± 1.0) than their matched controls (10.6 ± 0.5), this was without significant differences ($Z=1.6; p>0.9$).

	Schizophrenics [aged 12-20]	Controls [aged 12-20]	Controls [aged 21-30]
ONT-usual	-2.59 (-0.67)	-0.09 (0.29)	0 (1)
ONT-unusual	-2.09 (-0.54)	-0.73 (0.29)	0 (1)
MRT-MR2	-0.81 (-0.21)	-0.60 (0.31)	0 (1)

Table 3: Z-Scores for the Three Groups (Mean and SEM)

	Controls	Patients	Z-test; sig.	Controls	Patients	Z-test; sig.
ONT-usual	93.5 (1.3)	82.3 (2.9)	3.1; 0.002	629.6 (38.6)	753.6 (88.3)	0.8; N.S
ONT-unusual	65.3 (3.4)	49.5 (3.5)	2.7; 0.006	843.4 (70.2)	982.5 (133.1)	0.5; N.S
MRT-MR1	73.2 (5.1)	73.3 (6.4)	0.02; N.S	1481.5 (72.8)	1618.8 (106.3)	0.7; N.S
MRT-MR2	66.0 (5.3)	62.4 (5.8)	0.5; N.S	1642.8 (81.4)	1576.4 (72.2)	0.3; N.S

Table 4: Mean Reaction Times (SEM) and for Correct Responses of the Two Adolescent Groups

Discussion

Visual processing deficits are an integral component of schizophrenia and are a sensitive predictor of the disease [24,25]. Adolescence is a particularly important period with regard to normal brain maturation processes, making it a susceptible period for the development of schizophrenia. Studies have shown neuroanatomic abnormalities in adolescents with schizophrenia [26] During adolescence schizophrenic traits are likely to manifest themselves in carriers of the disease that do not manifest in healthy individuals of the same age. Despite this accumulated knowledge, there has been a relative paucity of studies assessing cognitive functioning in schizophrenic adolescents compared with schizophrenic adults. In the current study we used tools that require different levels of visual processing, and examined the visual perception functioning of schizophrenic adolescents compared with two groups of healthy people: adolescent and young adult.

One of the prominent expressions of schizophrenia is impairment in reality testing [27]. The impaired reality testing is one of the main symptoms of psychosis, but can also exist when schizophrenic patients are not in the midst of a psychotic episode [25]. One of the tools for diagnosing impaired reality is the Rorschach test. The Rorschach test is a visual perception assessment in which the subject is asked to say what he sees in inkblots presented to him. The analysis of the Rorschach test relies on the statistics of perceptual variation in the normal population versus that of the various disorders [28]. That is, statistically, there is a direct relationship between impaired reality testing and damaged perception and visual processing in schizophrenic patients [29]. The healthy brain develops continually during adolescence. By using two age groups of healthy controls and schizophrenic patients we demonstrate the impact of inadequate visual function on the reality testing deficiency. Nevertheless, it is important to emphasize that our work has focused on cognitive testing of visual

perception, and we did not test the degree of impairment of reality testing in patients.

The visual system is probably the most significant for our ability to understand and cope with the environment. This is the most complex mental system and occupies large parts of cortical and sub-cortical brain areas. We readily can recognize objects despite the fact that they are partially obstructed from our view. This seemingly easy task actually involves multiple cortical and sub-cortical brain areas specialized in interpreting complex and ambiguous visual [30,31]. Nevertheless, the study of visual perception requires us to simplify problems so that they can be investigated under controlled circumstances. In the current study we used two perceptual tests. The first is the mental rotation test (MR), which is designed to examine the integrity of the dorsal visual pathway. This test deals with the spatial orientation of objects. The second one is the object naming test (ONT). This second test refers to the ventral cortical pathway and deals with the semantic and categorical components involved in the understanding of visual objects and situations.

The ONT has two conditions: the usual condition includes pictures of objects taken from a conventional viewpoint and hence easier to identify, and the unusual that includes pictures of objects taken from unconventional perspective. Young healthy adults can generally recognize pictured objects even if they are presented from unusual view points. One widely held hypothesis regarding the recognition of disoriented objects is that the memory holds multiple representations of objects (such as different iconic viewpoints). When a stimulus from an unusual view is processed, the image is compared with these multiple representations. Perceptual recognition will therefore rely on searching through these representations [32]. An alternative hypothesis suggests that objects are held in the memory in one or a few typical orientations [33,34,35]. In this case normalization processes, such as MR, are used to align incoming stimuli with these 'typical' representations [36].

The ONT test actually does not examine only perception but also semantic memory and semantic search. Thus, the combination of the task of "general knowledge" (from the WAIS) is designed to rule out the influence of irrelevant parameters relating to search and retrieval of information from semantic memory. The results indicate that although a significant correlation was found between performances in the usual conditions of the ONT of each group separately, there was no difference between the two groups in general knowledge task. Meaning that, the reason for the decline in schizophrenic group in ONT performance is not related to the interference of semantic memory within the assignment. Our results show a significant difference in the function of both tests compared to age-matched healthy subjects. The obtained differences were more prominent in ONT than in MR [Table 3 and 4; Figure 3]. Since there was no difference in the functioning of general knowledge, we can interpret that the patients are less impaired in semantic memory-related processes, but differentially impaired in primary as well as secondary perceptual processes. The results can explain the bizarre responses of schizophrenic patients while performing the Rorschach perceptual diagnostic test. Our results highlight the difficulty that schizophrenic patients have in organizing visual information. This difficulty prevents them from "seeing and interpreting" the world in a way that is compatible with normal perception.

could explain the larger gap in Z-scores of ONT (related top-down processes) than the differences of Z-scores in MR test [38].

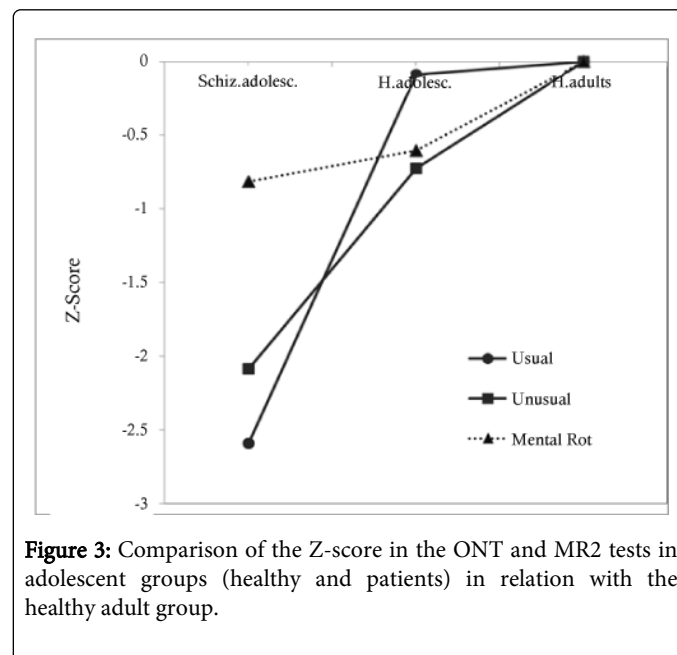


Figure 3: Comparison of the Z-score in the ONT and MR2 tests in adolescent groups (healthy and patients) in relation with the healthy adult group.

In summary, these results raise the possibility that ambiguous situations that require top-down combined processing and feedback are damaged significantly. To our knowledge, this is the first study on the developmental damage to high perceptual processing of sensory information and its contribution to impairment in reality-testing. Moreover, the findings that these functions continue to develop in normal adolescence (Figure 3), and that there is a correlation between the age of the appearance of the disease and perceptual processing, raises the possibility that the disease is not the essence of degenerative disorder. Rather, it appears that the processes that have already developed before the outbreak of the disease - are preserved.

Conclusions

The current study supports the notion that perceptual impairment (related to damage to reality testing), and the specific brain damage in schizophrenia is not innate, rather it occurs close to the disease onset [38-43]. This understanding can help in the treatment of people at risk, before the onset of the disease. This may allow preventing or diminishing the severity of symptoms, especially those that are key in the functioning of these individuals, even beyond situations of psychotic episodes. This important finding has implications for determining prognosis, as well as for therapy. Our results suggest that future research should investigate therapy approaches teaching the patient to use preserved feedback mechanisms to deal with the damage in testing-reality.

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Contribution of the authors

Dr. Ariela Gigi - the initiator of the study: Created the computerized of tests, statistical analysis of the results and wrote the

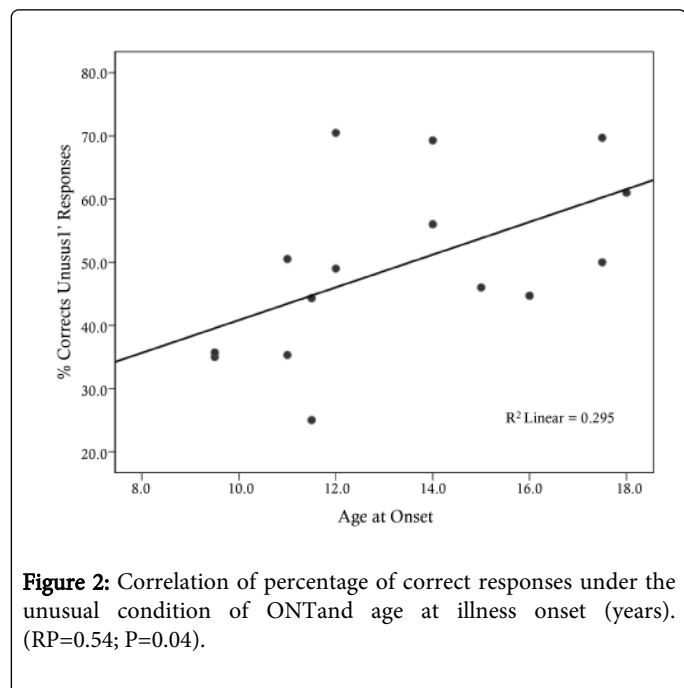


Figure 2: Correlation of percentage of correct responses under the unusual condition of ONT and age at illness onset (years). (RP=0.54; P=0.04).

The present study also found a significant association between the age of onset and performance in unusual and MR tasks: as much as age of onset was earlier, the functions of perception were more damaged. It is easy to explain this finding by referring to the comparison between the functioning of healthy adults [Figure 3] and adolescents which shows that the performance in the usual task is identical in both healthy groups. However, MR and unusual tasks performance continues to develop during adolescence. Thus, as the age of onset is earlier, there is more damage to the development of these perceptual abilities. These results refute the possibility that the injury is related to innate brain damage and/or to medication effect. Neuro-psychological studies in schizophrenic patients show significant damage to the frontal cortex, which is important for top-down processes [37]. This

article; Dr. Daniela Karni - executive research: Recruiting subjects, tested the subjects, converted the results and prepare them for statistical processing; Dr. Oren Eilam - search and collection of relevant articles for the writing.

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Statement of Interest

None.

Ethical Standards

We assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

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