Car driving in schizophrenia: can visual memory and organization make a difference?

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Abstract

Purpose: Driving is a meaningful occupation which is ascribed to functional independence in schizophrenia. Although it is estimated that individuals with schizophrenia have two times more traffic accidents, little research has been done in this field. Present research explores differences in mental status, visual working memory and visual organization between drivers and non-drivers with schizophrenia in comparison to healthy drivers. Methods: There were three groups in the study: 20 drivers with schizophrenia, 20 non-driving individuals with schizophrenia and 20 drivers without schizophrenia (DWS). Visual perception was measured with Rey-Osterrieth Complex Figure test and a general cognitive status with Mini-Mental State Examination. Results: The general cognitive status predicted actual driving situation in people with schizophrenia. No statistically significant differences were found between driving and non-driving persons with schizophrenia on any of the visual parameters tested, although these abilities were significantly lower than those of DWS. Conclusion: The research demonstrates that impairment of visual abilities does not prevent people with schizophrenia from driving and emphasizes the importance of general cognitive status for complex and multidimensional everyday tasks. The findings support the need for further investigation in the field of car driving for this population – a move that will considerably contribute to the participation and well-being.

Implication for Rehabilitation

- Unique approach for driving evaluation in schizophrenia should be designed since direct applications of knowledge and practice acquired from other populations are not reliable.
- This research demonstrates that visual perception deficits in schizophrenia do not prevent clients from driving, and general cognitive status appeared to be a valid determinant for actual driving.
- We recommended usage of a general test of cognition such as Mini-Mental State Examination, or conjunction number of cognitive factors such as executive functions (e.g. Trail Making Test) and attention (e.g. Continuous Performance Test) in addition to spatial-visual ability tests (e.g. Rey-Osterrieth Complex Figure test) for considering driving status in schizophrenia.

Keywords

Car driving, cognition, schizophrenia, visual perception

Introduction

Community mobility plays an important role in health, well-being and participation. For many people, driving a car is a meaningful occupation that contributes to engaging in other instrumental activities of daily living, social networking and work, which are positive indicators of participation and well-being [1,2].

Palmer et al. [3] ascribe the ability to drive to functional independence in schizophrenia and report that 43% of middle-aged and older persons with schizophrenia drive. Other studies reported that individuals with schizophrenia have approximately two times more traffic accidents for every driven mile than individuals without schizophrenia [4]. In a study involving driving simulation, individuals with schizophrenia were more prone than controls to crossover lanes, to cross the center dividing line more often, to get into a collision approximately 2.5 times more frequently, and to drive at a significantly slower than average speed [5].

The mechanism by which schizophrenia influences driving is not well understood. Most research in this field examines the influence of antipsychotic drugs on driving performance [6–9]. However, driving in traffic is a complex, multidimensional everyday task and may be affected by many factors other than antipsychotic medication, including severity of disease symptoms, cognitive abilities and experience [1,3,5,10].

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Despite the fact that there is no generally accepted driver’s performance model, driving is conceptualized as involving at least three dimensions or levels: basic cognitive abilities necessary for driving, actual skills for maneuvering the vehicle in traffic, and the more executive, goal-directed aspects of driving [11–13]. Among the cognitive abilities, visual abilities are one of the most important since 90% of all information processed by drivers is visual and a range of visual abilities affect driving performance [14].

The few studies that have focused on visual perception in persons with schizophrenia have produced conflicting results. Nevertheless, they have presented reliable evidence of deficits in different aspects of visual perception in this population [15,16], including failure in visual integration of fragmented stimuli, decreases in accuracy of figure copying and visual memory [17,18]; difficulties with contrast detection and motion perception [16]; deficits in perceptual organization that are observed mainly when the task stimuli has fewer configurable properties, and when task-relevant processing requires top–down influence [15]. Dysfunction of visual abilities reflected in poor functional outcomes [15].

The importance of visual perception for driving has already been recognized in populations with severe neuropsychological impairments. Visual organization and visual immediate recall skills were found to discriminate between drivers with and without suspected dementia, and evaluation of these skills was considered useful for prediction of fitness to drive in persons after stroke [19–22].

Visual perception impairment is not the only cognitive deficit in schizophrenia [23]. Cognitive impairments associated with schizophrenia may include difficulties with memory, attention, executive functions, problem solving, processing speed and capacity, sensory-motor processing, abstraction and concept formation abilities [24,25].

Taken together, these findings raise the question whether visual perception affects fitness to drive in people with schizophrenia in the same manner as in other populations. We undertook to explore how mental status, visual memory and visual organization combined with motor response differentiate between driving and non-driving persons with schizophrenia and drivers without schizophrenia (DWS).

**Methods**

**Participants**

Sixty individuals, with a mean age 34.32 (SD = 11.12, range 20–60) participate in the study: 20 drivers with schizophrenia or schizoaffective disorder (as classified by the DSM-IV-TR); 20 non-driving persons with schizophrenia or schizoaffective disorder and 20 DWS or schizoaffective disorder (Table 1).

We recruited the persons with schizophrenia from day care units or the part-time hospitalization unit of a regional mental health center. Inclusion criteria for the group of drivers with schizophrenia were holding a valid driver’s license, defining themselves as having had actual driving experience within the past half a year, and not having a caretaker. Exclusion criteria were mental retardation, head injuries, physical disabilities and psychotic state due to substance and alcohol abuse. All suitable persons were requested to participate in the study until the desired quota of participants was reached. The 20 participants in the driving group included 9 men (45%) and 11 women (55%), 17 (85%) of them were diagnosed with schizophrenia, 14 (70%) were living with their own family, 10 (50%) were not working and 18 (90%) were taking a first-generation antipsychotic medication.

The participants in the non-driving group consisted of 7 men (35%) and 13 women (65%) with schizophrenia (N = 15, 75%) or schizoaffective disorder (N = 5, 25%). Most of them were living with their own family (N = 12, 60%), were not working (N = 14, 70%), and were taking a first-generation antipsychotic medication (N = 16, 80%).

There were no significant differences between groups of drivers and non-drivers with schizophrenia in age of illness onset, number of hospitalizations and years of illness (Table 1), although non-drivers with schizophrenia experienced more hospitalizations than drivers.

DWS were recruited by convenience sampling. Half of them were men (N = 10, 50%); most were living with their own family (N = 15, 75%) or alone (N = 5, 25%), and were working (N = 17, 85%) or studying (N = 3, 15%).

The three groups were matched for gender (x^2 = 1.21, p > 0.05) and age (Table 1). A significant difference was found in years of education between DWS and persons with schizophrenia (either driving or non-driving; Z = −4.78, p < 0.001; Z = −4.48, p < 0.001 accordingly; Table 1). Age of obtaining a license and years of driving experience were similar in the two driving groups (Table 1).

**Measures**

Rey-Osterrieth Complex Figure test (ROCF) [26] consists of a task completed in two phases: direct copying of a complex dimensional figure and drawing of the figure by recall from memory following a given delay. ROCF is a popular structured tool widely used to analyze visuospatial abilities, planning, organization, problem-solving strategies and visual memory [27]. The ROCF includes 18 separate components and the maximum score for completion of both tasks (direct copying and recall) is 36. Visual encoding is reflected in percent of copying, calculated by dividing recall score by direct copying score. Visuospatial organization is scored on a six-point scale in which higher scores indicate a lack of organizational strategies [27]. Changing of pen
The MMSE has good test–retest reliability in psychiatric inpatients (0.83<r<0.89) [36]. Internal consistency of all test items was found for the Hebrew version [38]. Convergent validity of the Hebrew version was based on comparison with the Wechsler Adult Intelligence Scale verbal scale (r=0.77, p<0.001) and performance scale (r=0.66, p<0.001) [38].

### Procedure

The study received approval from the institutional review board according to principles outlined in the Declaration of Helsinki. Each participant gave written informed consent to take part in the study after the procedure had been fully explained. The study was conducted between October 2006 and December 2007. An occupational therapist administrated the measures during one session of one and a half hours. The order of the measures given during each session was random. Demographic data were collected from participant’s medical charts.

### Data analysis

The data were analyzed with SPSS 17 (Chicago, IL). Normal distribution assumption was tested for continuous variables initially and the following ones met the assumption: age, years of illness, years of driving experience, recall, delayed organization and percent of copying. Differences between two groups on these measurements were assessed with the t-test, while differences in number of hospitalizations, age of illness onset and age of obtaining a driver’s license were analyzed by Mann–Whitney test.

Differences between the three groups on direct copying, direct organization, MMSE and education were analyzed by the Kruskal–Wallis test, followed by Mann–Whitney test for each two groups to determine the source of the differences. Differences in recall, delayed organization and percent of copying between the three groups were analyzed with one-way ANOVA. Significant differences were identified by the Tukey post hoc test.

Discriminant analysis was performed to determine whether the ROCF and MMSE scores distinguish between participants of the three study groups: non-drivers with schizophrenia, drivers with schizophrenia and DWS. Further logistic regression analysis was used to assess prediction of driving status among persons with schizophrenia. Measurements that reached statistical or practical significance were entered into the analysis (MMSE, percent of copying and recall). Since education affects MMSE results, it was controlled among groups with schizophrenia. The level of significance was set at 0.05 for all statistical tests.

### Results

The results section shows differences between drivers and non-drivers with schizophrenia in the ROCF scales and general mental status in comparison to DWS. In addition, it presents a discrimination model based on the above-mentioned measurements comparing the three study groups.

#### ROCF – direct copying and recall

A significant difference was found between the three groups in direct copying (χ²=16.2, p<0.001). Mann–Whitney test indicated that direct copying ability of DWS was significantly better than both non-drivers and drivers with schizophrenia (Z=−3.58, p<0.001, Cohen’s d=1.11; Z=3.48, p=0.001, Cohen’s d=1.08, respectively; Figure 1).

Analysis of variance demonstrated a significant difference in the ROCF recall score between the three groups (F²,57=26.08, p<0.001, r²=0.478). Post hoc analysis showed that DWS performed the test significantly better than both drivers and non-drivers with schizophrenia (Cohen’s d=1.54; Cohen’s d=2.27, respectively; Figure 1). Despite lack of a significant difference on this parameter between drivers and non-drivers with schizophrenia, it had medium effect size (Cohen’s d=0.64).

Percent of copying differed significantly between the groups (F²,57=21.96, p<0.001) due to the difference between DWS and the two groups of persons with schizophrenia according to the post hoc analysis (non-drivers with schizophrenia: mean 0.25, SD=0.17; drivers with schizophrenia: mean 0.38, SD=0.19 and DWS: mean 0.62, SD=0.17). Although there was no significant difference in percent of copying between drivers and non-drivers with schizophrenia, it had medium-to-large effect size (Cohen’s d=0.73).

#### ROCF – direct and delayed organization

A significant difference was found in direct organization between the groups (χ²=7.92, p<0.019). The results stem from differences between DWS and non-drivers with schizophrenia (Mann–Whitney test: Z=−2.77, p=0.006, Cohen’s d=1.03; Figure 2).

The difference was found in delayed organization (F²,57=7.77, p=0.001). Post hoc analysis indicated that delayed organization among DWS was significantly better than that of non-drivers and drivers with schizophrenia.

![Figure 1. ROCF scores on direct copying and recall in the three study groups.](image)
The discriminant functions significantly improved the prediction model from chance (Wilks’ $\lambda = 0.35$, $p < 0.001$, $N = 60$). As there were three groups, two functions were extracted. The first function, with eigenvalue of 1.42, contained all entered measurements: recall, percent of copying, MMSE, delayed organization and direct copying and organization. It accounted for 89.2% of the explained between-group variance. The second function’s eigenvalue of 0.17 did not significantly improve the prediction. Overall, 70% of the cases were correctly classified, with membership in the DWS group predicted with the greatest accuracy. Most errors were found in discrimination between driving and non-driving persons with schizophrenia (Table 2).

The structure matrix (Table 3) indicated that all ROCF parameters and MMSE score are strongly associated with the function that best predicts group membership (Function 1). Better copying abilities, recall and visual organization, and higher MMSE score characterized DWS. Yet, the parameter that contributed most to the discrimination was recall (Table 3).

As expected, discriminant functions means at group centroids of Function 1 (from $-1.286$ to $1.534$) varied more widely than ones of Function 2 (from $-0.357$ to $-0.208$), indicating that Function 1 contributed largely to the separation of the groups with recall as the largest contributor.

Since the discriminant model differentiated less precisely between persons with and without schizophrenia, logistic regression analysis was used to predict driving status among persons with schizophrenia. The regression model was significant ($\chi^2 = 17.92$, $p < 0.001$) and explained 48% ($R^2 = 0.481$) of the variance. The largest contributing parameter for prediction of driving status among persons with schizophrenia was the MMSE score (Table 4): the higher the MMSE score, the higher the probability of the person with schizophrenia to drive (odds ratio $= 0.487$).

Discussion

This study adds to the growing evidence of the association between cognitive status in schizophrenia and every day activities, such as driving [3,24,39]. The driving and non-driving persons with schizophrenia exhibited a variety of difficulties in copying abilities, visual memory, visual organization and generalized...
cognitive abilities, but only the general mental status differentiated between them. Thereby the results demonstrate that impairment of visual abilities did not prevent people with schizophrenia from driving and emphasizes the importance of general cognitive status for complex and multidimensional everyday tasks, such as driving.

Our findings on visual perception deficits in the persons with schizophrenia are consistent with studies that showed visual memory impairment characterized by difficulties in organizational processing and retention in this population [15,18,40]. People with schizophrenia have difficulty allocating cognitive and conceptual resources to incoming data in short-term visual memory. In addition, they fail to use stored memories or regularities of previous input in current perception processing, which makes it less effective [15,41,42].

Since processing of visual information is crucial during driving [14,43], it was expected that the visual perceptual parameters would discriminate between drivers and non-drivers with schizophrenia [14–16,18,19,27,43]. Surprisingly, we did not find a significant statistical difference between these two groups on the visual perception parameters, although there was a trend for higher visual functioning among drivers with schizophrenia compared to non-drivers.

The lack of difference in direct copying between driving and non-driving persons with schizophrenia assumes that in schizophrenia basic cognitive abilities required for direct copying (such as visual attention) are less reflected in everyday functioning. On the other hand, these findings may be explained with the former reports suggesting that persons with schizophrenia are capable of basic structural information processing in visual storage [15,16]. However, this processing did not account fully for visual recall [15,18]. Recall is a complicated task with additional cognitive demands such as planning, decision making, strategies in constructing the figure [27]. These cognitive abilities are known as executive functions and found to be impaired in schizophrenia [18,24,27]. Thus, visual recall, as evaluated by the ROCF, reflects cognitive high-level processes in addition to visual perception abilities. The difference in recall between driving and non-driving persons with schizophrenia reaches meaningful effect size. This suggests that high-level cognitive processes may be a key parameter for complex everyday functioning such as driving, rather than specific cognitive abilities. This assumption strengthens with in meaningful effect size’s difference in copying percent that emphasizes memory processes, such as encoding.

The importance of the general cognitive abilities as they pertain to driving was prominent in another finding of this study. Briefly tested cognitive status was found to be a more distinguishing factor than visual perception in context of driving among persons with schizophrenia. There are two possible approaches to cognitive evaluation in schizophrenia in the context of everyday functioning: to evaluate each cognitive component in depth (as demonstrated in the ROCF test), or to use a general score of cognition (as demonstrated by the MMSE) [3,24,35,44,45]. The results of the present study emphasize the importance of general cognitive status for driving as complex and multidimensional everyday task, which requires to take a step from basic cognitive operations toward high-level mental actions [46]. Driving in traffic carries the potential for the compensation of deficits in performance capacity to enable meaningful occupation, and general cognitive abilities enable such compensation [10].

In this study, the non-driving participants had never obtained a driving license. Because this might reflect their premorbid functioning, we needed a control for this parameter [15] – one that was supplied by keeping the education levels of the two groups with schizophrenia the same [47]. Nevertheless, non-drivers had a higher number of hospitalizations than drivers, reflecting perhaps a more severe course of illness in the former group. The course of illness is an important factor in interpreting the results of the study, since some illness characteristics, such as an increased level of disorganization, correlate with dysfunction of visual perception [15].

The study has some limitations, beginning with the method of recruitment. In addition, enrolling persons with schizophrenia from only one regional mental health center may make the results difficult to generalize. In this research just one assessment of visual perception was used, while there are variety tools for evaluation of this cognitive function. Clear criteria for visual perception impairments in schizophrenia and model to their evaluation in context of driving need to be developed. In future studies, it will be important to evaluate the influence of both visual perception and general cognitive abilities on actual driving skills while controlling for a variety of intervening factors in order to develop theoretically based evaluation of driving performance in context of schizophrenia [46]. One such factor that should be considered is antipsychotic medication, since it affects both cognitive performance and everyday functioning, such as driving [6–9].

Conclusions

Today, driving is a subject of interest as a meaningful occupation by itself and as one of the most important enabling factors for participation and engagement in other significant occupations, such as work, leisure and social communication. Thereby, research in this field will considerably contribute to promotion of health and well-being. The results from this study demonstrate that direct application of knowledge acquired from other populations regarding driving with focus on specific cognitive constructs, such as visual ability, and their specific impact on driving might not be appropriate in schizophrenia. In this case, a unique approach to evaluation should be designed. Based on the study results we recommended usage of a general test of cognition such as MMSE, or conjunction number of cognitive factors such as executive functions (e.g. Trail Making Test) and attention (e.g. Continuous Performance Test) in addition to spatial-visual ability tests (e.g. ROCF) for considering driving status in schizophrenia. The study findings contribute to initial knowledge in the field of driving evaluation in schizophrenia and emphasize the need for further investigation with more comprehensive model of measurements and using additional study design.

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Declaration of interest

The authors report no declarations of interest.

References

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