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Computerized cognitive remediation improves verbal learning and processing speed in schizophrenia

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Abstract

Computerized cognitive remediation has resulted in improved executive function in schizophrenia, whereas results with regard to verbal memory were inconsistent. In the present study, 42 inpatients with schizophrenia were randomly assigned to a computerized cognitive remediation group or to a treatment-as-usual (TAU) control group. The remediation group received 15 sessions of computerized cognitive training (Cogpack) over a 3-week period. Neurocognitive functions were assessed at the beginning and end of this period. Compared to the control condition, remediation training resulted in improvements in verbal learning, processing speed and executive function (verbal fluency). The results indicate that cognitive remediation may lead to improvements beyond those of executive function.

Keywords: Schizophrenia; Cognitive remediation; Verbal memory; Processing speed; Executive function

1. Introduction

Cognitive deficits are an essential feature of schizophrenia (Saykin et al., 1994), in particular, those of attention, executive function and verbal memory (Mueller et al., 2004). The observed deficits are not accounted for by the effects of medication as they are also evident in neuroleptic-naïve patients (Saykin et al., 1994), and impairments remain stable over years (Heaton et al., 2001). Unaffected relatives of patients with schizophrenia have also been found to have neuropsychological deficits (Dollfus et al., 2002), which suggests that they are transmitted within families and may constitute a vulnerability factor. A number of attempts have nonetheless been made to remediate neurocognitive dysfunction in patients with schizophrenia.

Cognitive training schemes were administered either in small groups with patients practicing mental tasks under supervision (e.g., Olbrich and Mussgay, 1990) or else in computerized form (e.g., Medalia

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et al., 1998). The first generation of cognitive training studies focused mainly on tasks of long-term concentration such as the continuous performance (Benedict et al., 1994) or letter cancellation test (Olbrich and Mussgay, 1990), and patients showed some gains due to training, although results were inconsistent (Suslow et al., 2001). More recently, neuropsychological key dysfunctions were targeted directly, i.e., those of executive function, attention and verbal memory (Wykes et al., 1999; Medalia et al., 2000; Vauth et al., 2001; Bell et al., 2001; Bellucci et al., 2002; van der Gaag et al., 2002), with varying success. Most authors reported some improvement in executive function, including working memory due to training (Wykes et al., 1999; Vauth et al., 2001; Bell et al., 2001; Bellucci et al., 2002; van der Gaag et al., 2002). The results on improvements in verbal memory are discrepant. In their metaanalysis of the effect of cognitive remediation in schizophrenia, Pilling et al. (2002a,b) concluded that there was no benefit to verbal memory. However, closer inspection of the studies, which the authors used to evaluate the combined effect, reveals that some contain no memory training and others no measures of verbal memory. For instance, the study of Tompkins et al. (1995) conferred no remediation training, and the one by Benedict et al. (1994) consisted of vigilance but no memory training. Wykes et al. (1999) restricted their memory measures to those of working memory, i.e., sentence span. Among the studies cited, only Medalia et al.'s (2000) contained distinct training and measurement of verbal memory. There were no significant group differences reported in this study. In contrast, Bellucci et al. (2002) reported significant improvement in prose recall due to training. Two weekly individual computerized sessions of cognitive training were employed in both studies; Bellucci et al. (2002) administered 16 sessions with a variety of cognitive training tasks, and Medalia et al. (2000) conducted 10 sessions devoted solely to memory training. It is conceivable that either the number of sessions or the type of training program contributed to the differences in results.

In the present study, patients received daily computerized training over 3 weeks, totalling 15 sessions. The training program, Cogpack (Marker Software), targets a variety of functions, among them verbal memory. The program adapts the task difficulty to the individual performance. A randomised control group received treatment as usual (TAU). Assessment measures contained those of verbal memory, executive function and mental processing speed.

2. Materials and methods

2.1. Participants

Forty-two inpatients of the Psychiatric Hospital Stiftung Tannenhof, Wuppertal took part in the study. (Table 1) All patients met ICD-10 criteria of chronic schizophrenia as assessed by the treating psychiatrist. None of the patients showed evidence of neurological disorder, substance abuse or learning disability. The majority of patients (N=35) were diagnosed as belonging to the paranoid subtype, another three to

Table 1
Group means and S.D.s of demographic, clinical and neuropsychological variables

	Cognitive remediation (N=21)	Treatment as usual (N=21)
Age, range	32.2 (8.5), 21–60	31.6 (8.9), 20–49
Sex (m/f)	14/7	14/7
Education (years)	10.3 (1.2)	10.3 (1.1)
Duration of disorder (years)	5.5 (4.8)	6.8 (5.5)
Chlorpromazine equiv. (mg)	550.92 (323.9)	584.8 (318.1)
Verbal IQ estimate		
I	25.0 (7.5)	22.7 (5.3)
II	25.3 (7.8)	23.1 (5.5)
Trail B (s)		
I	122.4 (55.4)	151.0 (58.7)
II	90.8 (37.5)	116.5 (37.6)
Prose recall immed.*		
I	24.9 (6.9)	23.0 (9.3)
II	31.9 (10.3)	24.2 (10.1)
Prose recall delayed*		
I	19.4 (7.0)	18.7 (8.8)
II	27.6 (9.1)	22.0 (10.5)
Word fluency*		
I	67.4 (21.4)	68.7 (22.0)
II	76.5 (21.5)	70.8 (21.2)
Digit symbol*		
I	39.0 (13.2)	37.7 (8.9)
II	45.4 (12.7)	38.9 (10.4)

I refers to the first, and II refers to the second assessment. Variables with asterisks showed significantly greater improvement in the cognitive remediation than the TAU group.

the disorganised and one patient each to the catatonic, the residual and the undifferentiated subtype. All participants gave their informed written consent prior to inclusion. Their medication was maintained constant during the time of the study. All participants received a small remuneration for their participation in the study.

2.2. Design

Participants were allocated randomly to a treatment (N=21) and a waitlist control group (N=21). Both groups were given an initial neuropsychological assessment and another identical one after 3 weeks by a trained psychologist who was unaware of group membership. In-between, the treatment group received 15 daily 45-min sessions of cognitive remediation, additional to the treatment as usual (TAU), while the waitlist control group received only TAU. All participants were inpatients throughout the time of the study.

2.3. Treatment

A computerized training program (Cogpack, version 5.9j; Marker Software) was used for cognitive remediation. The program consists of a series of 30 computer tasks tapping different functional areas at varying levels of difficulty. Some tasks are designed to train attention and concentration, others verbal, spatial and numerical ability and memory or fast reaction time. The tasks are attractively designed, and the level of difficulty is adaptive. Whenever a task is solved at a set speed, the program goes on to another type of task; at lower levels of proficiency, that is, if a task is not solved, a similar task is given, and the training effect is calculated. If it is above 10%, a third and last task of that type is given, otherwise a different type of task follows immediately. This way, patients should be neither bored by easy tasks nor frustrated by repeated failure. Training sessions took place in small groups of up to six patients at a time; an attendant was present at all times to introduce patients to the use of computers and assist them whenever they needed help. The training was labelled “computer game sessions.” All patients of the treatment group took part in all sessions.

While patients of the treatment group received cognitive remediation, those of the control group attended occupational therapy. Following the waitlist period, they also received the computerized remediation program.

2.4. Measures

Neuropsychological testing was carried out by a clinical psychologist. Whenever available, parallel test forms were used at the second assessment.

(1) IQ estimate: Multiple Word Recognition Test (MWT; Lehrl, 1989). It consists of 37 items with five word creations of which one is meaningful. (2) Word fluency (Borkowski et al., 1967). The score represents the number of words beginning with S, G, U, N, F, T, J and P, which subjects can generate within 1 min each. (3) Trail Making Test B (Reitan, 1979). Trail B consists of a random display of numbers and letters, which have to be connected in sequence. The time taken to complete the tasks constitutes the score. (4) Digit Symbol test, a simplified version by Oswald and Fleischmann (1986) was used. Nine digits have to be replaced as quickly as possible, with a symbol shown at the top of the page. The score represents the number of correct symbols drawn within 90 s. (5) Prose Recall, German translation of the Logical Memory subtest from the Wechsler Memory Scale-Revised (Wechsler, 1987). Two short stories are read to the subject and are reproduced immediately and again after a delay of 30 min. The score represents the number of correctly reproduced elements of the story.

2.5. Data analysis

Groups were compared with regard to demographic data and neuropsychological data submitted to ANOVAs with a group×assessment occasion design. In the case of significant results, effect sizes are indicated in terms of η^2. Finally, change of neuropsychological scores was correlated with the demographic data in the treatment group.

3. Results

Groups did not differ significantly with regard to age, sex composition, years of education and dose of medication ($p>0.05$) (Table 1). There were also no significant group differences with regard to neuropsychological variables at the first assessment occasion. The neuropsychological data of both occasions were submitted to 2×2 factorial ANOVAs comparing groups and assessments. There were significant assessment and group×assessment effects with regard to the Wechsler prose recall test, with the treatment group showing greater improvement with regard to immediate [group×assessment: $F(1,40)=6.82$, $p<0.05$; Table 1] and delayed recall [group× assessment: $F(1,40)=8.41$, $p<0.01$; $\eta^2=0.17$]. Similarly, there were significant assessment and improvement effects observed in regard to the digit symbol test [group×assessment: $F(1,40)=4.67$, $p<0.05$; $\eta^2=0.10$] and the word fluency test [group×assessment: $F(1,40)=4.62$, $p<0.05$; $\eta^2=0.10$]. There were no significant effects regarding verbal IQ. While there was no significant difference between groups with regard to Trail B, both of them improved over assessments [$F(1,40)=30.81$, $p<0.01$; (Table 1)].

4. Discussion

The results indicate that computerized cognitive remediation training leads to significant improvement in regard to verbal memory, processing speed and executive function in patients with schizophrenia. Verbal IQ remained unaffected by treatment, and Trail B improved in both groups over assessment occasions.

These findings are inconsistent with a previous metaanalysis of cognitive remediation (Pilling et al., 2002a,b), which concluded that there was no benefit to verbal memory and a questionable one to executive function. A number of factors could account for the discrepant outcome. Patients in the present study were slightly younger and had a shorter duration of the disorder than those of most of the studies referred to by Pilling et al. (2002a,b). It is conceivable that the effect of cognitive remediation decreases with chronicity. Another factor concerns the treatment schedule. In most of the previous studies, treatment was administered in distributed fashion with up to three weekly sessions (Benedict et al., 1994; Medalia et al., 1998; Wykes et al., 1999), whereas it was given under massed conditions with five weekly sessions in the present study. Cognitive function may respond better to massed stimulation and exercise than to distributed training. Bell et al. (2003) also noted that treatment intensity may contribute to the duration of effects. Participants of the present study were inpatients. Previous cognitive remediation studies are divided among inpatients (Hermanutz and Gestrich, 1990; Medalia et al., 1998, 2000) and outpatients (Benedict et al., 1994; Field et al., 1997; Wykes et al., 1999; Vauth et al., 2001), indicating that the patient status is not of importance. It may, however, be essential for a massed treatment schedule as adherence is more difficult to ascertain in outpatients.

The present pattern of results suggests that functions were differentially affected by the remediation program. Patients of the treatment group showed more substantial improvement in declarative memory than attention span and word fluency. Attention and executive function have most frequently been evaluated in studies of cognitive remediation in schizophrenia. Results are contradictory with regard to attention, with some showing a significant effect (Wykes et al., 1999; Bell et al., 2003) and with some showing an effect on training tasks (Benedict et al., 1994; Medalia et al., 1998), which did not generalize to the assessment measures. In the present study, Trail B, a measure of selective attention, showed no treatment effect, although it has previously been shown to improve more with computerized training (Vauth et al., 2001; Bellucci et al., 2002). Measures of planning and processing speed have rarely been used, with the exception of the six elements test which showed a marginal effect. The digit symbol test has so far not been employed and showed significant improvement due to cognitive remediation. The present task was a simplified version of the original test and was standardized in a population of elderly individuals. It is conceivable that this simplified version possesses greater sensitivity in the lower performance range and is therefore more responsive to minor changes.

It is one of the shortcomings of the present study that the long-term effect of training cannot be investigated because patients in the control group received computerized cognitive training after the waitlist period. Wykes et al. (2003) and Bell et al. (2003) reported encouraging results 6 and 12 months following training. Another important question not followed up in the present study is the effect of cognitive remediation training on clinical symptoms. Small but significant effects have so far been reported on negative symptoms (Wykes et al., 1999; Bellucci et al., 2002; Bark et al., 2003). It is as yet unclear whether the improvements are due to specific interventions or whether they result from a general mental activation effect of computer tasks. Giving the control group some form of basic computer could have thrown light on this question. However, a generally stimulating effect could not account for the specific improvements in some but not other assessment measures. The present slender database allows in any case the conclusion that computerized cognitive remediation represents a useful addition to the treatment of schizophrenia.

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