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Cognitive improvement of schizophrenic patients: Enhancing cognition while positively enjoying computer-aided cognitive training

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Introduction

- Already Kraepelin (1913) and Bleuler (1911) have considered dysfunction of attention as a key symptom of schizophrenic illness. During the last two decades, however, cognitive dysfunction in schizophrenia has received broader scientific interest from psychiatrists and psychologists and a number of studies have reported deficits in memory, attention, executive functions, as well as visual-motor planning.
- At the same time it was discovered that cognitive dysfunction limits social and vocational functioning and tends to persist even after antipsychotic treatment. Because of these findings it was claimed that schizophrenic patients should receive cognitive training to influence the further course of their illness positively.
- The present study examines the effects of computer-aided cognitive training using motivational software that evokes positive emotions. We expect that this method of training is particular effective because (positive) emotions and cognition are addressed simultaneously.

Method

Participants

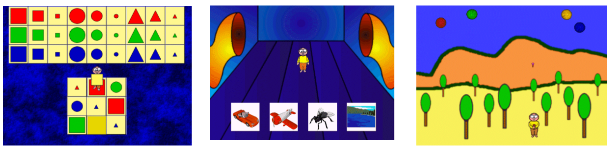
- 40 outpatients of the psychiatric hospital in Regensburg, Germany were recruited. All of them fulfilled ICD-10 as well as DSM-IV criteria for schizophrenia.
- Symptom levels were rated with the German Versions of PANSS (Kay *et al*, 1987), BDI (Hautzinger *et al*, 1993), Paranoid-Depressive Scale (PDS, Zerssen, 1976) and the State-Trait-Anxiety-Inventory (STAI, Laux *et al*, 1981).
- Cognitive functioning was tested with the Wisconsin Card Sorting Test (WCST, Young and Freyslinger, 1995), the German version of the California Verbal Learning Test (CVLT, Spreen & Strauss, 1998) and the subtests "tonic alertness (selective attention) and "phasic alertness" (reaction speed) of the "Testbatterie zur Aufmerksamkeitsprüfung" (test battery for the investigation of attention, TAP, Zimmermann and Fimm, 1993), which is a German computer test for several subtypes of attention
- 20 patients were included in the experimental group (EG), 20 patients matched by gender, age and educational level formed the control group (CG). The groups don't differ in any of the demographic measures shown in table 1, nor with regard to symptom level and cognitive achievement, except the measure for sustained attention (TAP tonic alertness) where the CG scores were better than the EG (t=1.89, p<.10).

Treatment

- The EG received a total of 20 sessions of cognitive training with 2 sessions per week using the cognitive training software X-Cog ® (Trapp, 2003, see detailed description below). The cognitive and psychopathological baseline measures described above were obtained before the first and the final investigation of these parameters was carried out after the last training session. The CG received no training but standard therapeutic treatment with occupational therapy as the centrepiece twice weekly for 10 weeks. Patients of the control group were tested with an interval of two months.
- X-Cog is a computer software that consists of 16 visuomotor, memory, executive and attention tasks and was explicitly designed to motivate patients as much as possible while 'playing' the exercises. Each task can be administered in five different levels of difficulty. The figures below present screen shots and short descriptions of some selected tasks.

Data analysis

- In order to avoid extensive repetitive testing for every single cognitive measure, a multivariate MANOVA (dependent variables: cognitive measures, between-subject factor: treatment group; within subject-factor: time of testing (pre-vs. posttest)) was performed. To examine, whether there was a similar effect of cognitive training on psychopathological outcome, the same general design was applied to psychopathological variables as dependent measures. After general testing, univariate MANOVAS for each dependent variable were carried out as post-hoc tests to determine whether there were differential effects for single cognitive or psychopathological variables.
- After completion of the training, patients of the experimental group were asked whether they had enjoyed cognitive training ("very much", "rather much", "undecided", "rather not", "not at all"), if they had found it helpful ("very helpful", "rather helpful", "undecided", "rather not helpful", "not helpful at all"), and if they would recommend it to other patients ("would recommend it", "would not recommend it").



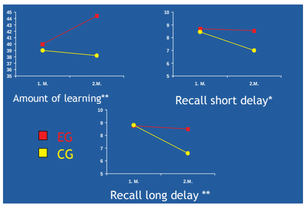
Figures: **left:** The missing tile has to be completed following the implicit logical rules for color, shape and size. **middle:** Kind, order and direction of different sounds have to be remembered. **right:** Passing comets have to be decomposed according to a changing recipe.

Effect	F(10/29)	p
Treatment	2.338	0.003
Time	5.555	< 0.0005
Treatm. X Time	2.795	0.018

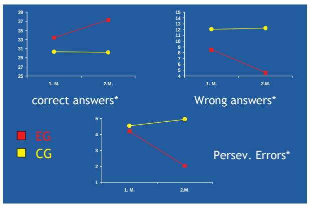
Multivariate MANOVA, all cognitive measures

Effect	F(7/32)	p
Treatment	.61	0.747
Time	5.56	0.006
Treatm. X Time	3.03	0.018

Multivariate MANOVA, all psychopathological measures



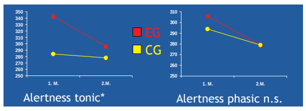
Cognitive measures MVGT



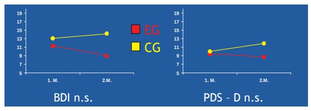
Cognitive measures WCST

Results

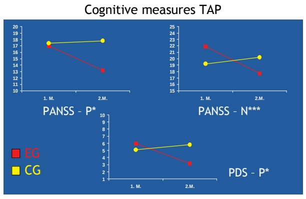
- All patients assigned to the experimental group remained in the cohort until the end of the training, hence no dropouts were found in this group. When asked for their opinion about the training 80% (16) of the patients found it "very helpful", 15% (3) "rather helpful" and only one participant (5%) remained "undecided". None of them rated training with X-Cog as "rather not helpful" or "not helpful at all". All patients seemed to enjoy training (90 % (18) enjoyed it "very much", 10% (2) "rather much") and all of them would recommend it to other patients.
- A multivariate MANOVA for the cognitive variables demonstrated significant main effects for "treatment group" (members of the experimental group scored better in cognitive tests), "time" (all patients were better at the second testing) and a significant interaction effect (EG improved in cognitive tests to a greater extent than CG). The results of the univariate MANOVAs conducted separately for each dependent variable are shown in the figures below and right.
- With regard to symptom scores, multivariate MANOVA demonstrated no significant main effect for "treatment group" (psychopathology across both measurements did not differ between EG and CG). However, a significant main effect for "time" (all patients were better at the second testing) as well as a significant interaction effect (EG improved to a greater extent in psychopathology than CG) was found. The results of univariate MANOVAs conducted separately for each dependent variable are also shown in Table 2.
- Significant interaction effects were found for positive and negative symptom levels measured by means of PANSS as well as for PDS-'paranoid thinking'. In all three measures improvement of psychopathology was observed in EG, whereas symptom levels remained unchanged in CG.
- No interaction effects could be found neither with depression (self- and extraneous rating), general anxiety (STAI-trait) nor with anxiety during testing (STAI-state).



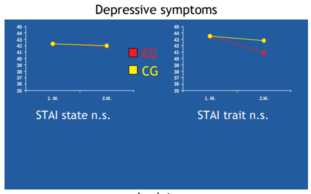
Cognitive measures TAP



Depressive symptoms



Positive and negative symptoms



Anxiety

Discussion

- This study highlights the positive effects of enjoyable computer-aided cognitive training. We found independent general effects of computer-aided cognitive training on cognitive achievement and psychopathology. When effects on cognition were analyzed in detail, positive effects on executive functions, working memory and a stabilizing effect on verbal memory could be observed. It is worthwhile noting that verbal (working) memory and executive functions have been demonstrated to be of significant influence on rehabilitation and "community functioning" (Green, 1996). However, the effects of training on attention are reaching no more than a (two-sided) 10% significance level. When the general effect on psychopathological scales was further analyzed, effects on positive symptoms (extraneous rating and self report) as well as negative symptoms could be found. Cognitive training lead to fewer psychopathological symptoms compared to the control group.
- The effects on working memory are not surprising since working memory is particularly involved in all tasks in all tasks of the training software. Working memory may be a core variable in schizophrenia as previously assumed by Kraepelin and Bleuler. It has been reported that while working memory tasks don't correlate with other achievement variables in healthy people, they do in cohorts of patients suffering from schizophrenia (Silver, 2003). It may therefore be assumed that working memory may be limiting the performance of other cognitive functions in schizophrenic patients. In our study, the variable for working memory correlates significantly with all other cognitive variables (r between -.315 to -.377, p between .048 and .016 two-sided). We therefore assume that enhancing working memory performance could be the key to improvement of more complex domains such as executive functions. This could lead to improvement of the overall illness.
- For memory tasks, the benefits of positive connoted stimuli have clearly been proven (Propper, 2004): Stimuli that give rise to positive emotions are more likely to be remembered than negatively connoted stimuli, which in turn are easier to remember than neutral stimuli. This may have its reason in the level of elaboration that stimuli undergo during presentation and encoding: Emotional stimuli are more likely not only to be rehearsed, but also to be visualized and embedded into personal recollections.For patients suffering from schizophrenia it has been found, that - among stimuli that could consciously be remembered during recall - positive connoted could be remembered best, followed by negative and neutral. However, among stimuli, where persons experienced a feeling of "familiarity" during recall while the presentation itself could not be remembered, this relation could not be found. In contrast, healthy control persons profit from emotionality for both types of stimuli (Danion, 2003). Perhaps, the 'game-like' character may provoke enhanced strategies to a stronger extent during encoding. Maybe this causes higher levels of elaboration, which in turn enhances working memory performance for EG during post-testing.
- In spite of some encouraging results our study suffers from several limitations: First of all our sample size of forty patients is rather small compared to those of other controlled studies (e.g. Bell *et al*, 2001, Medalia et al, 1998), what leads to a weaker statistical power and makes it harder to generalize our results. However, at least our effect sizes are comparably high (.56 - .85 compared to e.g. .15 - .25 in Medalia, 1998). In the main, the results presented in this paper only give preliminary clues. The question, whether and how long the described effects remain stable cannot be answered yet. In future it would also be interesting to identify variables, like medication or duration of illness, that influence the effects of neurocognitive training in the sense of moderating variables.
- Nevertheless, this study is the first controlled study that deals with effects of cognitive training - performed with a reduced frequency of sessions per week and during a rather long period of time - on *out*patients. We therefore hope that the results will be more stable, because the increase in cognitive ability can be easier put into practice and be stabilized in daily life.

References

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