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Reduction of Schizophrenic Deficits by Cognitive Training: An Evaluative Study

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Summary. The significance of training programmes was assessed in reducing cognitive deficits in schizophrenics. In a controlled clinical trial, which included 15 experimental and 15 comparison subjects, training was shown to be effective with regard to more complex cognitive functions rather than on an elementary level. Results are discussed with regard to theoretical and practical implications.

Key words: Neuropsychological deficits – Schizophrenics – Cognitive training – Controlled trial

Introduction

While very elaborate treatment programmes are available for social skills training in schizophrenics (e.g. Liberman et al. 1985, 1987), there has been relatively little research on cognitive deficits in this patient group. One of the few exceptions is a training programme developed by Brenner and associates (Brenner 1987). A common element in the various subsets of the training programme is the focus on attentional processes, which are thought to reflect an elementary ("basic") level of neurophsychological functioning, i.e. allocation of central processing capacity, and to be defective in schizophrenics. Brenner's view appears here to be in accordance with the extensive experimental literature on "core psychological deficiencies" in schizophrenia (for a recent review see Nuechterlein and Dawson 1984).

The present report deals with a controlled clinical study intended to assess the efficacy of cognitive training in schizophrenics. The design of the study deviates from previous research in two ways:

1. While in Brenner's programme cognitive and social learning aspects combine in a way that makes it difficult to determine their relative contributions, the present training scheme includes only cognitive elements.

2. While the assessment of training effects has generally focused on a relatively complex neuropsychological level involving cognitive processes beyond attentional capacities, the dependent measures in this study include elementary cognitive functions as well as more complex ones.

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Methods

Overview. In this controlled clinical trial an experimental group of 15 schizophrenic subjects participated in a cognitive training programme for a 3-week period. The same number of schizophrenics in a control group took part in a 3-week programme that was exclusively concerned with handicraft stressing creativity. Identical outcome measures were applied to both groups before and following training procedures.

Subjects. The subjects were inpatients at the Central Institute of Mental Health, Mannheim, FRG. Nine experimental and eight control subjects were males. All met the diagnosis of schizophrenia according to RDC (Spitzer et al. 1978). The majority of patients displayed at least some degree of overt psychotic symptomatology while attending the programme.

Subjects were assigned to the training scheme in the order of their admission. The experimental group was complete first. No significant difference was found between the experimental and the control group means for any of the following variables: age (31.6 vs 29.7 years), education (10.3 vs 10.2 years), duration of illness (5.0 vs 3.3 years), number of hospitalizations (4.4 vs 3.1), BPRS (Overall and Gorham 1976) total score before (46.0 vs 44.9) and at the end of the programme (36.7 vs 37.5), and neuroleptic dosage in chlorpromazine equivalents (Jahn and Mussgay 1989) before (332 mg vs 370 mg) and after intervention (293 mg vs 372 mg). Both groups showed a significant clinical improvement while attending the study, as indicated by an analysis of variance of BPRS scores ($F(1.28) = 20.48$, $P < 0.001$).

Training Procedures. Subjects performed their respective tasks at their own pace. In the experimental procedure they participated in a training programme made up of different cognitive paper and pencil tasks of moderate complexity: adding (or subtracting) extensive rows of numbers; ordering numbers; finding a common denominator for a given set of words or screening the set for semantically deviant elements; separating relevant from irrelevant elements in a picture; linking digits and symbols according to predetermined rules; copying visual displays; recognizing and recalling words and visually presented symbolic and geometric material. With regard to the cognitive processes involved, the tasks described here were thought to represent mental arithmetic, reasoning and concept formation, verbal and visual recall, and visuomotor coordination. The control condition focused on manual creativity. Subjects here were engaged in activities like painting, doing collages and modelling with small pieces of plasticine.

The training was incorporated into standard inpatient treatment. The two programmes were carried out on a relatively short-term, but intensive basis, offering four 1-h sessions weekly for a period of 3 weeks. Group size varied from two to eight patients. Both types of training were carried out by two students who had graduated in psychology. In order to minimize confounding effects of social exchange, each participant was asked to attend to his own tasks and not to communicate with other group members.

Dependent Measures. Cognitive functioning was assessed at two levels of complexity. An elementary cognitive level concerned attentional processes, which were assessed here by two simple reaction time (RT) tasks, involving motor responses (i.e. button presses). One of them refers to the so-called crossover paradigm, first published by Rodnick and Shakow (1940), which tests the subject's ability to maintain an attentional set. In this task each imperative stimulus, a tone, is preceded by a warning signal. Varying the time between warning signal and tone yields series of regular and irregular preparatory intervals. The term "crossover" is commonly used when RTs are longer under regular preparatory conditions than under irregular ones. The present study applied a modification of the original paradigm – that proposed by Steffy and Galbraith (1974).

While the crossover task primarily concerns sustained attention, the other RT paradigm involved focused on the capacity for attentional shifts. Here subjects had to react to stimulus presentations at two different modalities (i.e. light and tone), which shifted in a random way. For this type of experiment, Sutton et al. (1961) were the first to report cross-modal RT retardation in schizophrenics.

The two simple RT tasks certainly reflect very elementary mechanisms of cognitive functioning. Other investigators (e.g. Nuechterlein and Dawson 1984) have emphasized different experimental procedures like the Continuous Performance Test or the Span of Apprehension Test to assess cognitive dysfunctions in schizophrenics. However, they focus on the identification of markers of vulnerability.

Various tests were applied to assess cognitive functions of a more complex nature. All tests selected have shown deficiencies in schizophrenics according to reports in the literature. Tasks have included the Labyrinth Test (Chapius 1959), the Embedded Figures Test (Witkin et al. 1971), the d2-Test (Brickenkamp 1962), and the so-called K-L Test (Dücker and Lienert 1965). In the Labyrinth Test a maze has to be mastered. In the Embedded Figures Test, subjects are required to detect specified geometrical objects in a complex background. d2 involves letter cancellation at a rapid pace, and the K-L Test adding (or subtracting) and storing extensive rows of numbers.

In addition to the measures of cognitive functioning, two rating scales were included which primarily assessed social behaviour: the NOSIE (Honigfeld et al. 1976) and a Disability Assessment Schedule (DAS) subscale dealing with inpatient behaviour (Jablensky et al. 1980). These measures were supposed to indicate the extent to which a training programme that has been explicitly limited to cognitive elements nevertheless influenced patients' social behaviour.

Data Analysis. A series of data analyses was performed. The present report gives the results of analyses of covariance (ANCOVA), conducted for each of the dependent measures, using the Biomedical Computer Programs (BMDP; Department of Biomathematics, UCLA 1981). Raw data entered into 2,2-factorial matrices according to the two training procedures outlined (i.e. cognitive vs creative) and the two time points of assessment. In order to control for patients' clinical state and for drug effects BPRS total scores and medication (expressed in chlorpromazine equivalents) were included as covariates. As indicated above cognitive training did not affect BPRS scores and neuroleptic dosage. Analyses of variance (ANOVA) were conducted as well. Here only the main effects regarding pre- and post-training comparison turned out to be more pronounced. The other results were identical with the ANCOVAs.

Results

Table 1 displays means and standard deviations of each of the dependent measures for the experimental and control group at pre- and post-training assessment. In addition, the results of the ANCOVAs are shown. The findings in Table 1 may be summarized as follows:

1. With regard to elementary cognitive tasks ANCOVAs yielded only a significant main effect for groups, which refers to crossover RT. As indicated in Table 1 experimental and control subjects displayed marked differences in both pre- and post-training assessment. Crossover RT is the only dependent measure in the present study in which initial level of performance between groups turned out to be unbalanced. This finding is most likely due to the large interindividual variation of crossover RT.

Inspection of Table 1 also seems to suggest that schizophrenics have improved under both training conditions with regard to RT retardation when signal modality shifts from visual to auditory stimulation. In fact, an ANOVA had yielded a significant main effect. However, ANCOVA did not confirm any significant effect, indicating that the reduction in retardation was rather due to improvements in the patients' clinical state than to training procedures.

2. Turning to the more complex cognitive tasks a quite uniform pattern of results across the functions examined seems to emerge from Table 1. Relative to the manual creativity procedure, the subjects who participated in cognitive training displayed higher improvement rates from pre- to post-treatment assessment. For three of the measures investigated ANCOVAs showed significant main effects. Post hoc analyses by *t*-test revealed that pre- vs post-training comparisons were only significant in experimental subjects, a finding which – for two variables – is also reflected by significant ANCOVA interaction effects. The three measures showing reliable effects of cognitive training refer to the following tasks (improvement rates in brackets): letter cancellation (18%), basic arithmetic (30%), and detection of geometrical figures (90%).

3. With regard to social behaviour data analysis did not show any significant results for the measures applied in this study. It thus appears that the effects of the cognitive training programme did not generalize to social behaviour dimensions.

Discussion

As a main result the present study indicates that neuropsychological dysfunctions in schizophrenics can be effectively reduced by cognitive training. The improvements encountered here have been achieved in tasks demanding flexible processing of visual material, signal (letter) identification and basic mathematical operations.

Table 1. The outcome of cognitive training and a creativity program in schizophrenics

Variables	Cognitive training (n = 15)				Creativity training (n = 15)				ANCOVA			
	Assessment: Pre		Post		Assessment: Pre		Post		Source	*df*	*F*	*P*
	Mean	SD	Mean	SD	Mean	SD	Mean	SD				
Elementary												
									G	1, 26	6.82	<0.05
Crossover RT (ms)[a]	−3.6	62.3	−18.3	48.7	41.1	72.6	14.0	55.9	A	1, 26	2.64	
									G × A	1, 26	0.04	
Crossmodal RT (ms)[b]:									G	1, 26	0.00	
shift from light to tone	116.9	118.3	74.1	71.8	121.1	112.1	81.2	80.3	A	1, 26	1.42	
									G × A	1, 26	0.01	
Complex												
Labyrinth Test:									G	1, 26	0.02	
speed + accuracy	9.1	12.0	13.1	9.5	10.2	9.5	11.9	8.3	A	1, 26	0.19	
									G × A	1, 26	0.49	
									G	1, 26	1.92	
Embedded Figures Test (s)	97.4	59.1	52.2	53.2	107.8	51.2	103.5	61.4	A	1, 26	7.47	<0.05
									G × A	1, 26	13.03	<0.01
Letter cancellation (d2):									G	1, 26	0.23	
number of letters processed	307.0	65.9	362.5	71.7	339.5	49.1	343.9	57.7	A	1, 26	4.70	<0.05
									G × A	1, 26	6.47	<0.05
									G	1, 26	0.85	
% errors	6.8	6.5	4.8	5.5	9.0	4.9	6.5	5.0	A	1, 26	2.47	
									G × A	1, 26	0.21	
Mental arithmetic (KLT):									G	1, 26	0.09	
number of problems processed	28.1	12.3	37.0	20.9	29.1	13.5	34.6	16.4	A	1, 26	4.88	<0.05
									G × A	1, 26	0.58	
									G	1, 26	0.38	
% errors	35.6	26.2	22.8	26.3	26.7	19.4	25.6	25.0	A	1, 26	0.54	
									G × A	1, 26	2.25	
Social												
									G	1, 26	2.59	
Nosie: Total score	208.5	19.6	212.3	20.1	199.5	27.2	201.1	25.3	A	1, 26	1.46	
									G × A	1, 26	0.00	
									G	1, 26	4.01	
DAS: Subscale score	4.6	2.1	2.9	2.1	5.7	3.5	4.3	3.1	A	1, 26	0.90	
									G × A	1, 26	0.00	

The table shows raw means and SDs in elementary and complex cognitive tasks and in social variables. In addition, ANCOVA results are displayed according to the Biomedical Computer Programs (BMDP), Programme 2V. G = Training group, A = assessment

[a] Values > 0 indicate longer RT under regular compared to irregular preparatory intervals

[b] Values refer to differences in RT between crossmodal (light-tone) and ipsimodal (tone-tone) sequences of stimuli

The training programme was administered for a 3-week period, mostly with patients in an acute psychotic state. It appears reasonable to anticipate that a more extensive training programme, applied to schizophrenics outside psychotic episodes, may result in even more substantial gains.

Treatment effects in this study concerned a more complex cognitive level, leaving elementary (attentional) mechanisms that are indexed by crossover and crossmodality RT paradigms virtually unchanged. This finding does not appear to be particularly exciting, in view of the fact that the training procedure – in line with cognitive programmes currently in use – primarily included tasks of medium-level complexity. Nevertheless, two noteworthy implications emerge.

First, in response to an adequate treatment regimen schizophrenics can apparently improve in overall neuropsychological functioning, even though elementary deficits may persist. This pattern of results might perhaps best be explained by assuming instigation of compensatory mechanisms. If this is correct, it calls for a revision of commonly held beliefs. Training programmes may achieve success not be restoring a deficient repertoire, but largely through the development of novel cognitive strategies. Thus, a promising goal of future work in this field should be the identification of compensatory strategies and of training techniques to promote them.

The other issue raised by the findings of the present study refers to the unitary concept of schizophrenic symptomatology. According to this view higher-level cognitive failure and even florid psychotic behaviour are due to a common pathogenetic denominator, involving elementary cognitive deficiencies. To the extent that our report bears on this relationship, the available data are not in support of it. Training effects became manifest on a more complex cognitive level, with no parallel changes within the elementary domain.

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