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Computer-assisted Attention Training in Schizophrenics

A Comparative Study

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Summary. The evaluation of a computer-assisted attention training program is compared with a cognitive group training program. Both programs were devised to reduce cognitive deficits in schizophrenics. The training programs were given to 30 acute schizophrenics and 30 healthy subjects. Both were shown to be effective in reducing distraction of schizophrenics in reaction-time tasks. By means of training, schizophrenics may attain the same results in reaction time tasks as healthy individuals. The results are discussed under theoretical, methodical and practical aspects.

Key words: Schizophrenia – Modality shift – Cognitive training – Computer-assisted attention training

Introduction

The empirically developed "cognitive therapy" for schizophrenics [1] has been used more frequently in recent years in the standard treatment of hospitalized patients in the form of the "integrated psychological therapy program for schizophrenics" (IPT). The therapy is based on the concept of basic disorders [11], which emphasizes among other things a disturbance of attention as characteristic of the schizophrenic deficit of information processing.

The five sub-programs of IPT do not only treat basic disorders, but in the sense of a "broad-spectrum therapy" also influence social and communication disorders. Most of the evaluation studies which have been carried out so far ([1, 2, 6, 7] for review see [8]) showed improvement of clinical symptoms and social skills.

One of the few exceptions to positive influence of IPT on specific basic disorders (for example on attention deficits) has been reported by Brenner et al. [1]. There are no other proven results, although such disorders of information processing in schizophrenic patients have been shown frequently in reaction-time tests of experimental psychology [7, 10, 12].

The present study therefore tried (1) to reduce the variety of cognitive therapies of IPT in a training group to a computer-assisted training program for basic attention performance; (2) to test the possibility of installation of a computer-assisted training on a ward and to consider whether this training method is suitable compared with expensive group therapies, and whether schizophrenics can be motivated to participate in a computer-assisted training.

Subjects and Methods

In the so-called *experimental group* 10 schizophrenic patients took part individually in a computer-assisted attention training (15 times during 3–4 weeks). Ten patients of a *control group* were instructed by the therapist in small groups of 3–5 members (cogni-

Table 1. Data of examined schizophrenic patients (ICD 295.3) and of healthy test persons

	Age median (standard deviation)	Years of school (range)	Duration of illness
Experimental group ($n = 10$)	31.5 (18–52)	11.0 (9–15)	6 weeks–2.6 years
Control group ($n = 10$)	30.0 (22–60)	11.3 (9–15)	3 weeks–10 years
"0" group ($n = 10$)	31.5 (22–54)	10.6 (9–15)	5 weeks–6 years
Healthy subjects ($n = 30$)	27 (24–37)	13.0 (12–14)	

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tive differentiation, communications and social training with social interactions from the trainer). A third group of 10 schizophrenic patients did not receive any kind of specific psychological training *("0" group)*. To obtain a reference point for the degree of attention deficits of acute schizophrenic patients in comparison to healthy subjects, 30 healthy college students were asked to perform the reaction-time tasks.

The patients were allocated to the respective groups as follows. On three admission wards all acute-schizophrenic patients (ICD 295.3) were asked to participate voluntarily in the study. The volunteering patients were randomly allocated to the three patient groups. About 50% of all patients asked did not take part in the study, since they did not expect hospitalization for weeks or since they could not be motivated to participate. All patients were treated with major tranquilizers (average daily neuroleptic dose in chlorpromazine equivalents 150–750 mg). There was no difference between the three groups.

Features of the test persons are shown in Table 1.

Training of the Experimental group

The patients of the experimental group undertook different exercises in training selective acoustic and visual attention within the 30 min of the exercise sessions.

Continuous Performance Task. At the reaction key of a personal computer they reacted as quickly as possible to visual stimuli. Three variants of the Continuous Performance Task (CPT) were offered. Average reaction time, hits and misses were fed back to the patient immediately after finishing the task.

Reaction Time Task. At the "Vienna Reaction Apparatus" simple reaction tasks and "go/no-go" tasks had to be performed, using feedback to the patient as well.

Music Task. Short but perceptible breaks were built into tunes of different kinds and lengths. The breaks had to be registered by pressing a key. The patients were told the difference between their registered breaks and real breaks after finishing the task.

Differentiating Noises. Different everyday noises (motors, waterdrops etc) were played by tape and had to be identified.

Letter Recognition. Single letters or combinations of letters had to be selected and counted from texts of different lengths.

Labyrinth Test. A labyrinth test [4] had to be worked out. Time and missing rate were documented. Feedback of the last three tasks took place after the training session.

Training of the control Group

As in the communication training of the IPT the trainer chose newspaper articles with a limited information content and without highly emotional contents. After the article had been read aloud by one patient, questions about the content were asked. Unknown terms were explained. The patients had to reproduce the content.

During the second half of the session, also lasting 30 min, the patients learned card games (i.e. "horse ball"). First the cards were introduced and put in order – similar to the card exercise in cognitive differentiation of the IPT. Then the rules of the game were introduced successively, until the game ran smoothly. In these exercises, cognitive power and differentiation, readiness for reaction, power of concentration and memory and communicative ability were assessed.

Pre-Post Measurements

All test persons took part in a reaction-time task developed by Sutton et al. [13], the so-called "modality shift paradigm", for about 10 min. Reaction times on acoustic and visual impulses, which are varied from run to run, were measured. Two variations were used: both impulses originated from different sensory modalities (i.e. sound-light, crossmodal) or from the same sensory modality (i.e. light-light, ipsimodal).

The cognitive performance of the patients was also assessed by the attention-stress test d2 [3] and the labyrinth test [4].

Doctors who were not involved in the training program assessed the social, professional and family functioning of these patients on the Global Assessment Scale (GAS). Clinical symptoms were judged on the 18 items of the Brief Psychiatric Rating Scale (BPRS). Mood and paranoid tendencies were rated by the patient on the PD scale of von Zerssen. Measurements were made before the training and after 15 sessions.

Statistical Analysis

Reaction times. From all subjects at least 20 reaction-time measurements per combination (sound-sound, light-light, sound-light, light-sound) were available for the pre- and post-evaluations. The medians of the single reactions were calculated separately for the four combinations. Analysis of variance (ANOVA) with the factors "group" (30 healthy subjects, 30 schizophrenics) and "succession of modalities" (cross, ipsi) were calculated separately for reactions on light and sound stimuli. The last factor was regarded as the measuring-repetition factor. Analyses of variance with the factors "group" (experimental group, control group, "zero" group) and "measuring point of time" [1, 2] and "succession of modalities" (repetition of stimuli, change of stimuli) were calculated separately for both conditions (reaction on light, sound) using the reaction time data of the patients exclusively. The last two factors were regarded as repetition factors.

By analysis of covariance it was assessed how far (independently of the initial status) differences in the degree of "modality shift" between the groups were present at the final examination after training. Since we were interested in the specific attention deficits in the sense of a "modality shift", we additionally calculated reaction-time differences between the crossmodal and ipsimodal conditions. These differences were scrutinized by analysis of covariance.

Rating Scales (GAS, BPRS, PD-S) and Psychometric Tests (d2, Labyrinth Test). For each of the other 12 dependent variables, ANOVA with the factors "group" (experimental group, control group, "zero" group) and "measuring point of time" [1, 2] were calculated. Since average initial values differed between the groups, we calculated analyses of covariances as well. The initial values were entered in the analysis as covariants.

Results

Reaction Times of Healthy Subjects in Comparison with Patients

Comparing mean reaction times of patients and healthy subjects at the first measurement, one can see that schizophrenics react significantly more slowly than healthy test persons [$F(1, 58) = 10.16$], on acoustic as well as on visual stimuli. Contrary to the results of other investigations [9] our study does not only show a significant "modality shift effect" on sound stimuli in schizophrenics but also in healthy subjects [$F(1, 58) = 16.48$].

Schizophrenics showed considerably longer reaction times on light stimuli than healthy subjects when the stimulus changed. This is shown by the interaction group × succession of modality [$F(1, 58) = 3.84$; $P = 0.07$]. Only when reacting on visual stimuli did schizophrenics

Table 2. Average reaction times (x [ms]) and standard deviations (SD) at the first and second measurements of patient groups and of healthy subjects

Reactions on succession modality		Measurement 1				Measurement 2			
		S-S	L-S	L-L	S-L[a]	S-S	L-S	L-L	S-L
Experimental group	x	295	336	346	373	267	295	325	341
	SD	(42)	(92)	(28)	(46)	(31)	(35)	(25)	(43)
Control group	x	301	315	365	401	280	287	337	364
	SD	(72)	(57)	(78)	(94)	(45)	(43)	(51)	(74)
"0" group	x	315	342	356	373	315	354	351	372
	SD	(77)	(88)	(84)	(84)	(92)	(111)	(77)	(94)
Healthy subjects	x	265	280	273	288				
	SD	(39)	(45)	(29)	(38)				

[a] S-L, Sound-light

Table 3. Results of analysis of variance (ANOVA) for reaction times on acoustic (sound) and visual (light) stimuli. ANOVA: three groups (experimental group, control group, "0" group); points of measurement (1, 2); succession of modalities (ipsi, cross)

	df	ANOVA: F-value		COVA: F-value	
		sound	light	sound	light
Main effects					
Group (grp)	2,27	0.96	0.30	4,92[a]	0.19
Measurement (m)	1,27	5.47[a]	8.17[b]		
Succession of modality	1,27	19.30[b]	15.51[b]		
Interactions					
grp × m	2,27	2.48	1.48		
grp × sm	2,27	1.73	0.39		
m × sm	1,27	0.17	0.53		
grp × m × sm	2,27	0.93	0.36		

[a] $P<0.05$
[b] $P<0.01$

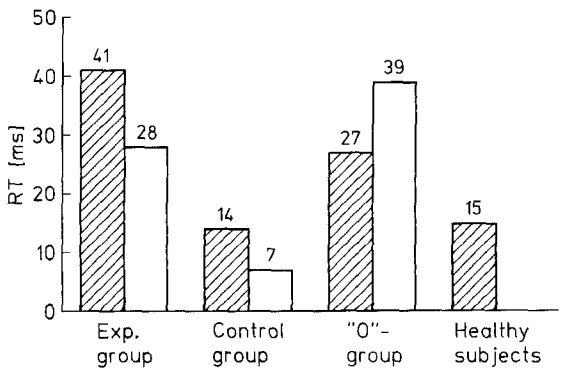

Fig. 1. "Modality shift" on acoustic stimuli in three schizophrenic patient groups and in healthy subjects. *RT*, Reaction time. ▨ First point of time of measurement; □ second point of time of measurement

show a stronger "modality shift effect" than healthy subjects.

Comparing reaction times of healthy subjects with those of schizophrenic patients at the second measurement the following observations can be made: schizophrenics react significantly more slowly than healthy subjects on visual stimuli only [$F(1, 58) = 30.16$]. Reaction time on acoustic stimuli does not differ significantly from that of healthy subjects [$F(1, 58) = 3.61$].

The reactions of schizophrenics after a change of stimulus are not slower than in healthy subjects; the "modality shift effect" cannot be stated any more [$F(1, 58) = 1.69$] (compare Table 2).

Mean Reaction Times of the Patient Groups

All three patient groups reacted more quickly on acoustic and visual stimuli at the second measurement than at the first one. This can be shown by a significant main effect for the pre- and post-measurements [$F(1, 27) = 5.47$, $P \leq 0.05$] (cf. Table 3). However, in the "0" group this effect is not visible in reactions on acoustic stimuli, considering average reaction times between the first and the second measurements. These differences between the groups are pointed out in the interaction "group × pre- and post-measurements" as well [$F(2, 27) = 2.48$].

Reaction Time Differences

A significant group effect can be demonstrated, when *reaction time differences* ("modality shift") are evaluated by analysis of covariance. The major result was that the reaction time difference of training groups between ipsi- and crossmodal succession of stimuli ("modality shift") decreased during training. In both training groups "modality shift" at the second measurement was considerably smaller than in the "0" group. This significant group effect, however, is only shown in reactions on acoustic stimuli [$F(2, 27) = 4.92$; $P \leq 0.05$] but not in that on visual stimuli [$F(2, 27) = 0.19$].

Rating scales (GAS, BPRS, PD-S)

Results of the ANOVA show that improvement of symptoms can be established in all valuated fields, not only by

Table 4. Medians *(x)* and standard deviations (SD) for 12 features divided into groups and points of time of measurement (1, 2)

		Experimental group		Control group		"0" group	
		1	2	1	2	1	2
GAS	*x*	46.2	55.9	51.0	60.6	49.4	60.0
	SD	9.2	11.5	9.1	9.6	10.3	6.6
BPRS							
Anxiety/depression	*x*	16.0	12.3	15.9	11.7	14.0	12.9
	SD	4.9	4.2	3.0	2.9	4.5	4.2
Anergia	*x*	12.3	11.2	11.2	9.7	11.7	10.5
	SD	3.1	4.2	3.2	4.3	2.5	2.8
Thought disturbances	*x*	8.9	5.9	8.2	6.0	7.2	6.4
	SD	3.7	2.3	5.3	2.6	4.5	4.0
Activation	*x*	8.6	5.8	8.1	6.6	10.0	7.3
	SD	3.9	3.8	4.6	3.4	1.3	2.7
Hostility/suspiciousness	*x*	6.1	4.1	5.6	5.1	7.7	6.4
	SD	3.2	1.6	2.2	3.2	3.5	3.1
PD-S'							
Hostility	*x*	8.4	5.3	12.0	10.2	8.6	4.7
	SD	6.0	5.5	7.8	7.1	8.0	5.3
Depression	*x*	17.2	9.4	20.5	16.5	14.5	11.6
	SD	12.2	5.6	12.7	11.3	7.3	4.9
Labyrinth test III							
Time [ms]	*x*	171	154	214	168	143	133
	SD	109	91	111	89	56	75
Error	*x*	3.4	3.3	6.5	6.0	4.2	3.1
	SD	3.2	3.0	2.6	2.4	3.0	2.6
Attention stress test d2							
Total number	x	347	375	310	357	339	384
	SD	97	94	109	112	111	122
Error	*x*	30.4	18.4	9.8	13.0	9.0	11.7
	SD	19.8	13.7	5.4	12.5	4.4	9.2

the doctors but also by the patients themselves, within 4 weeks [$F(1, 27) \geq 6.60$]. Differences between the groups cannot be demonstrated even when initial values of the first measurement are considered as covariants [$F(2,27) \leq 2.97$) (compare Tables 4, 5).

Attention Performances (d2-test, Labyrinth Test)

Efficiency (number of items) in the *d2 test* increased significantly from the first to the second measurement [$F(1, 27) = 30.90$]. The number reached approximates that of healthy subjects [3].

This tendency of approximation to the performance of healthy subjects after training can also be seen when considering the quality of test performance (number of errors). At the second measurement no differences between groups can be shown, even when initial values are partialized out by analysis of covariance [$F(2, 27) = 0.66$].

In the *labyrinth test*, patient groups did not improve through exercise [$F(1, 27) = 2.97$]. Significant group differences were already obvious at the first measurement. Results of analysis of covariance therefore show that no training effect of different kinds can be claimed between the groups. "Practice makes perfect" does not apply here. [$F(2, 27) = 1.69$); (cf. Tables 4, 5).

Discussion

Our results show that deficits in attention performance ("modality shift") of schizophrenics can be improved by a cognitive training program within 4 weeks. The improvements found by us consisted in a reduction of the typical delay of reaction in a "modality shift" paradigm, but not in better attention performance within the labyrinth test and d2 test (reported by Brenner et al. [2]). We think there are different attentional mechanisms involved, but such attentional mechanisms which are measured by reac-

Table 5. Results of analysis of variance and covariance for 12 features. ANOVA: three groups (experimental group, control group, "0" group); point of measurement (1, 2). COVA: three groups (experimental group, control group, "0" group); covariate first point of time of measurement

	ANOVA	[*F*-values]		COVA
	Main effects		Interaction	
	Group (grp)	Measurement (m)	(grp × m)	
	df (2, 27)	*df* (1, 27)	*df* (2, 27)	
GAS	1.00	26.10[b]	0.03	0.35
BPRS				
Anxiety/ depression	0.13	10.23[b]	1.05	0.38
Anergia	0.43	6.60[a]	0.29	0.28
Thought disturbances	0.07	15.06[b]	1.56	1.37
Activation	0.65	18.83[b]	0.60	0.44
Hostility/ suspiciousness	1.54	11.75[b]	1.38	1.64
PD-S′				
Hostility	1.67	9.28[b]	0.40	1.74
Depression	1.20	15.00[b]	1.38	2.97
Labyrinth test III				
Time [ms]	1.04	2.95	0.62	0.06
Error	4.70	0.95	0.25	1.69
Attention stress test d2				
Total number	0.23	30.90[b]	0.74	0.66
Error	5.59[a]	0.87	5.22[b]	0.38

[a] $P<0.05$
[b] $P<0.01$

tion time are certainly involved in the tasks of everyday life, and therefore are only one aspect of attention. Considering average reaction times of the experimental and the control group at the first and second measurement a distinct reduction of "modality shift" is shown. In the "0" group even a tendency for stronger "modality shift" effects can be found at the second measurement. Therefore susceptibility for distraction through the preceding stimulus in schizophrenics can apparently be definitely reduced by a training program.

Comparing reaction times at the second measurement with the results of healthy test persons, no difference can be found between healthy subjects and schizophrenics after training, either in the markedness of the "modality shift" or in the average speed of reaction time on acoustic stimuli. These approximations to the efficiency of healthy subjects occur independently of whether patients perform special elementary attention tasks individually or whether they take part in groups in an unspecific cognitive training with active interaction with the therapists and the copatients.

Olbrich and Mussgay [10], in contrast, did not find any increase in performance of the field of training using pure attention tasks.

Automated computer-assisted cognitive exercises without consideration of the emotional aspect cannot lead to better performances of attention than unspecific cognitive training methods, i.e. IPT; they do not, however, lead to worse results than the integrated therapy. This fact shows that utilization of personal computers in an effort to regain former cognitive performance in the sense of "drill and practice" is useful [5].

The following advantages of computer-assisted training are noteworthy: individual guidance of learning; in cases of failure, no exposure to the group; theoretically unlimited training possibilities; partial relief of the therapist; various forms of reinforcement; small steps in learning which lead to earlier success; reduced cost if many patients participate in one software program; this training method is accepted and schizophrenic patients can be motivated to participate in a computer-assisted training.

The question is which factors have caused the positive changes in both therapeutic groups. Was it the positive expectations of the trainers or the expectations of the patients with regard to the efficiency of an additional therapeutic measure? Such expectations were certainly present in the patients. By both training methods they experience that their performance may be better than they feared during the acute schizophrenic episode. Moreover, they experience that they themselves can do something for their health by being shown new possibilities in the handling of cognitive disorders. Helpless surrender to the disease is reduced by such training.

The influence of the trainers on the patients varied considerably between the two training groups. Apart from the welcome and "good bye", patients of the experimental group did not receive any social interaction during the 30 min of the training session. Improvement in this group can therefore not be due to social interactions. On the other hand, numerous contacts took place between patients and therapists of the control group while discussing newspapers and playing cards.

Our data show that schizophrenics can master simple tasks just as well as healthy subjects when they receive cognitive training in addition to standard psychiatric therapy. Improvement in the field of information processing can, however, not always be made visible by clinical and psychometric methods, but this becomes evident – as can be shown by reaction times – when appropriate methods are used.

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