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Behavioral Treatment of Parkinson's Disease Leads to Improvement of Motor Skills and to Tremor Reduction

BETTINA MOHR

VIKTOR MÜLLER

REGINA MATTES

University of Tübingen

REGINA ROSIN

Neurologische Universitätsklinik
Tübingen, Germany

BARBARA FEDERMANN

UTE STREHL

FRIEDEMANN PULVERMÜLLER

University of Tübingen

FRIEDEMANN MÜLLER

Neurologische Universitätsklinik
Tübingen, Germany

WERNER LUTZENBERGER

NIELS BIRBAUMER

University of Tübingen

The effects of psychological treatment of idiopathic Parkinson's Disease (PD) were investigated. Behavioral treatment focusing on control of motor activity was compared to a nonspecific psychological treatment. Patients were randomly assigned to 2 treatment groups with 20 patients in the behavioral group and 21 patients in the control group. The 2 groups were equivalent for age, demographic variables, and duration and severity of the illness. Twenty treatment sessions were held over a period of 10 weeks. Behavioral change was assessed by the Motor Performance Test Series (MPS), the Unified Parkinson's Disease Rating Scale (UPDRS) and by a psychologist's ratings and the patients' self-reports. Unspecific treatment effects were controlled by

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using several questionnaire measures. Results indicated that only behavioral treatment was effective in reducing tremor and in improving manual dexterity. We conclude that behavioral treatment is an effective supplement to traditional medical treatment with L-Dopa for improving motor performance and reducing tremor in Parkinson's disease.

Parkinson's Disease (PD) is a neurodegenerative disease leading to dysfunction of the basal ganglia. It is characterized by a disturbance of voluntary and involuntary movements manifested in the following cardinal clinical symptoms. At rest there is a rhythmic *tremor* with a frequency of 4–7 Hz due to alternating agonistic-antagonistic innervation of distal arm muscles and, rarely, of the legs. The second cardinal symptom is called *rigor*, a unique increase in muscle tone or rigidity that often has a cogwheel- or ratchet-like characteristic. The rigor predominantly leads to movement disorders of the trunk, resulting in a bent posture. The third cardinal symptom is *akinesia*, defined as difficulty initiating movements, paucity of spontaneous movements and slowness in the execution of movement (*bradykinesia*). These difficulties are often most apparent in the manner in which a patient rises from a bed and in the characteristic shuffling gait. Akinesia also leads to disturbed manual dexterity (writing, eating with cutlery), to hypomimia, to a reduced modulation of speech, and to reduced co-movements of the arms while walking (Birkmeyer & Riederer, 1985; Cote & Crutcher, 1991; Scholz & Oertel, 1993).

It is well known that the severity of the symptoms of a patient can dramatically change with psychological and task factors (Cleeves, Findley, & Gresty, 1986; Jankovic & Marsden, 1993). For example, frequency and intensity of tremor at rest is strongly influenced by the emotional state of the patient. The tremor is often inhibited during the performance of voluntary movements and it may be absent during sleep (excluding REM-phases). During relaxation, the tremor is frequently reduced, and it increases when the patient is confronted with a difficult task, in particular if the patient is afraid of failing on the task. This suggests that systematic use of relaxation training in the context of a behavioral treatment may lead to a reduction of tremor, in particular in situations where psychological factors normally cause impaired performance.

Parkinsonian symptoms not only depend on psychological factors; it is also well known that motor impairments can suddenly disappear due to task requirements and context of the task. It has been demonstrated that patients with PD can easily catch a ball approaching them, whereas they are often not able to pick up a ball from the floor when being told to do so (Ludin,

Please address all correspondence to: Dr. Bettina Mohr, Institute of Medical Psychology and Behavioral Neurobiology, University of Tübingen, Gartenstraße 29, 72074 Tübingen, Germany; phone xx49-7071-29 4222; fax: xx49-7071-29 5956; e-mail: pumue@mailserv.zdv.uni-tuebingen.de

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1988). Furthermore, Parkinson patients' performance improves when external stimuli are present that can serve as cues. For example, PD patients have less gait problems when walking on a striped floor or when fixating on a distant target (Birkmeyer & Riederer, 1985). It is very possible that systematic use of such cues by PD patients will lead to a reduction of motor problems.

Due to their apparent behavioral deficits, patients with PD often suffer from performance anxiety and from fear of observation by others. This may cause additional emotional stress and may lead to further deterioration of motor performance and increase of tremor (Grundmann, 1990). It has also been demonstrated that the proportion of patients who meet the criteria for anxiety disorder is significantly higher in PD patients compared to the normal population (Harvey, 1986; Lauterbach & Duvoisin, 1991). Hubble and Venkatesh (1995) hypothesize that anxiety and social phobias, including fear of falling and fear in public places, may largely reflect the patients' awareness of their physical disabilities. This provides additional motivation for a behavioral treatment aimed at reducing such stress.

In PD, the dopaminergic pathway from the substantia nigra to the striatum is disturbed due to loss of nerve cells and depigmentation in the substantia nigra pars compacta and locus coeruleus. This degeneration process leads to dysfunction of the basal ganglia (Cote & Crutcher, 1991). The cause of the gradual destruction of dopaminergic pathways in PD is still unknown. The goal of traditional therapy has been to replace the missing dopamine by oral intake of L-Dopa. Although this drug ameliorates the motor symptoms of PD, it does not stop the degenerative changes in the substantia nigra. It is well known that, with increasing length of pharmacological treatment, the doses have to be increased in order to be effective. Moreover, L-Dopa produces harmful vegetative and psychiatric side effects (Kalat, 1992), which usually become worse after a patient has taken the medication for a long time. New medical approaches to overcome the limitations of L-Dopa therapy include surgical treatment, such as thalamotomy or transplantation of fetal dopamine cells into the striatum. However, because of the surgical risks and the lacking evidence of success of these interventions over time (Collier & Kordower, 1995; Goetz & Diederich, 1992) and the limitations of the treatment with L-Dopa, there is a strong need for additional alternative therapy approaches to PD.

Several studies have tried to improve gait, posture and limb coordination problems in PD patients by special exercise training programs in conjunction with medical therapy. Some studies have postulated that physical training improves patients' performance on tasks relevant in daily living (Franklyn, Kohout, Stern, & Dunning, 1981; Gauthier, Dalziel, & Gauthier, 1987; Gibberd, Page, Spencer, & Williams, 1981). However, such postulates were usually based only on outcome measures using patients' subjective ratings. Of course, it would be highly desirable to use objective measures in addition to subjective ones. A recent study by Pedersen and co-workers (Pedersen, Öberg, Insulander, & Vretman, 1990) used simultaneous electromyographic (EMG) recordings to assess gait and strength variables. After a 12-week physical training program Pedersen et al. did not find any improvements of motor symptoms of PD. In general, results from earlier studies of physical training programs in PD are rather inconsistent and inconclusive (for a review see Palmer, Mortimer, Webster, Bistevins, & Dickinson, 1986).

Psychological interventions aiming at improving the symptoms of PD have rarely been carried out. Ellgring and coworkers (Ellgring et al., 1990) conducted a study to reduce psychosocial problems of PD patients. In this study, 23 PD patients participated in a behaviorally oriented psychological program consisting of five 2-hour sessions over a period of 2 months. The treatment program included practice of various social skills (such as ordering and paying in restaurants, asking somebody for a seat on a bus, etc.) and therapeutic interventions to increase patients' activity level and to improve their acceptance of the illness. Behavioral techniques like cognitive restructuring, training in social skills and role play were used in order to improve patients' situations. Because the authors did not include any outcome measure for their treatment, there is no evidence that their therapy was effective in improving psychosocial problems.

Leplow and coworkers (Leplow, Bamberger, Möbius, & Ferstl, 1993) reported the application of behavioral techniques for the reduction of stress responses in PD patients. The major goal of this study was to improve patients' self-confidence and to reduce social withdrawal and other avoidance behavior. The authors provided a detailed description of the 12 sessions treatment program with 6 PD patients using muscle relaxation, role plays, and cognitive restructuring. Also in this study, the authors did not include any outcome measure to evaluate the effectiveness of the therapy. In another study by Leplow, Möbius, Bamberger, and Ferstl (1994) objective (EMG-recordings) and subjective (patients' tremor ratings) measures were used to evaluate the effects of the behavioral treatment program reported in the earlier study. This study was conducted in two separate groups with 10 patients per group. It was demonstrated that behaviorally oriented therapy was effective in reducing patient's subjective tremor estimation, although there was no reduction of tremor in the EMG recordings. Together with the study by Pedersen et al. (1990), these results suggest that therapeutic effects of the treatment of PD are hard to detect in EMG recordings. It appears that, up to this point, only subjective tremor measures suggest any improvement related to psychological (behavioral) treatment of PD.

The results of a controlled therapy study (undertaken with experimental and control groups, as well as several outcome measures) using behavioral techniques for improving motor skills and reducing tremor, especially in stressful situations, have not yet been reported. The present study was carried out in order to evaluate the effectiveness of a behavioral treatment concentrating on training of relaxation, motor skills, and coping with stressful social situations. It was intended to demonstrate the effects of the training with subjective and objective measures. The three main elements of the behavioral treatment were related to the three main aims of the therapy. These were the following: (a) reduction of tremor at rest, (b) improvement of motor performance relevant for everyday life (such as manual dexterity or gait), and (c) improvement of coping strategies relevant for the management of stressful situations. It was hypothesized that a group receiving behavioral treatment would reach one or more of these aims during a 10-week treatment interval. In order to control for nonspecific effects of the therapy, a second group was treated with a nonspecific psychological intervention. This control group received a 5-minute relaxation training and participated in frequent discussions about disease-related problems with psychologists, but no training of motor skills was performed, and no role playing or muscle relaxation training was applied to improve performance. The more precise prediction then was that the behavioral treatment group would show performance improvements over the course of the therapy relative to the control group. Because PD is a progressive degenerative disease, this also would allow for the possibility of strong deterioration occurring in the control group, but only slower decay can be observed in the behavioral group. A more optimistic view, however, is that the behavioral group would indeed show an improvement in one or more of the dimensions specified above, and that the control group would either maintain its level or become slightly worse.

Method

Subjects

Forty-one patients with idiopathic PD took part in the study. The patient sample was selected according to the following inclusion criteria: absence of major depression, dementia, or other psychiatric disorder using axes 1 and 2 of Diagnostic and Statistical Manual of Mental Disorders (DSM-III-R; American Psychiatric Association, 1987), and willingness of the patient to participate in therapy sessions twice a week for 10 weeks. No patient had a history of alcohol or drug abuse nor any other significant physical illness. Patients were recruited from the outpatient clinic at the Department of Neurology, University of Tübingen, from private neurological practices, and from a local PD self-help group.

Demographic Information and Medication Usage

The experimental group included 20 patients (5 females). The control group consisted of 21 patients (9 females). The severity of symptoms was assessed by using the modified Hoehn and Yahr (1967) scale, a scale with a minimum score of 0 (no impairment) and a maximum score of 5 (severe impairment). The Hoehn and Yahr scores of the patient sample ranged from 1.5 to 4. Most patients included in the study showed mild to moderate symptoms and were still in the earliest stages of the illness. There were no significant differences between the groups in either severity of symptoms or duration of illness, nor significant age differences. The level of education was also similar (years of

TABLE 1
DEMOGRAPHIC AND DISEASE-RELATED DATA FOR THE EXPERIMENTAL (BEHAVIORAL) AND CONTROL (NON-SPECIFIC PSYCHOLOGICAL TREATMENT) GROUPS

	Treatment Groups			
	BG (n = 20)		CG (n = 21)	
Measure	M	SD	M	SD
Age (years)	63.6	7.27	60.4	6.65
Hoehn & Yahr (1967) Stage	2.0	0.66	2.1	0.35
Duration of Illness (years)	6.5	3.87	7.9	4.88
IQ (WAIS-R)	116.3	13.15	117.1	11.57
Education (years)	10.4	1.78	10.5	1.80
WCST				
Categories	2.65	1.75	2.70	1.49
Milner error	8.40	7.47	8.88	7.74
Nelson error	8.35	5.68	8.52	4.25
Word fluency				
B	10.4	5.23	9.52	3.43
fruits	10.95	3.0	11.19	2.94
animal/M	10.1	3.39	9.35	1.73

formal education). Mean Full Scale IQ, as assessed by a reduced version of the Wechsler Adult Intelligence Scale (WAIS-R; Dahl, 1972; Wechsler, 1981), revealed no significant differences between the groups. All clinical and demographic data are summarized (see Table 1).

All patients received a combination of L-Dopa, with either a Dopa-agonist and/or an MAO-inhibitor, throughout the study. Medication remained unchanged during the 10-week treatment period. All pre- and posttreatment assessment was carried out at the same time of the day in order to exclude medication-induced performance fluctuations. The history of L-Dopa intake was approximately equivalent for the two groups.

Procedure

Subjects were randomly assigned to either the experimental group (behavioral therapy) or the control group (nonspecific treatment). In both groups, the psychological treatment was applied in addition to standard medication treatment. An initial screening was conducted several weeks before the onset of the first treatment session. This screening allowed the researchers to decide whether or not a patient would be appropriate for the study, based on specified selection criteria. An additional necessary condition for inclusion was the willingness of the patient to come to the sessions. Out of 55 patients taking part in the initial screening, 43 subjects were selected (3 were excluded for presence of a major depression, 1 for strong hallucinations due to drug treatment, 3 for dementia, and 5 for long travel distances). All patients included in the study were tested two times. The pretreatment assessment took place in the first week of treatment and the posttreatment assessment was conducted 1 week after the last treatment session. The behavioral treatment was administered in six separate groups; four groups included 3 patients each and two groups included 4 patients. The control group consisted of four groups: two groups with 5 patients each, and two groups including 6 and 7 patients, respectively. These groups were run sequentially over a period of 2 years. The control groups included more patients because in these groups the time-consuming training of individual motor skills was not performed. Two patients from the control groups did not complete their treatment. One patient stopped participating in the therapy after 10 sessions because of driving problems in winter. The other patient completed therapy but was not willing to come to the posttreatment examination due to severe family problems at this time. In the behavioral group there were no drop-outs. Finally, there were 20 patients in the group receiving specific behavioral treatment and 21 patients in the control group completing their nonspecific psychological treatment.

Treatment

The *behavioral treatment* included (a) relaxation training, (b) specific training of motor performance tailored to the problems reported by individual patients, (c) training of social interactions by role playing. Relaxation training was chosen to provide the patient with a method to voluntarily reduce tremor when he or she wanted to. (It is well known that tremor reduction can be induced by relaxation training, see above). In the motor training patients were trained to systematically use cues that facilitate their motor performance. Role-playing (including behavior rehearsal techniques and social reinforcement) and analysis of problematic social interactions were performed in order to develop strategies that reduce stress in complicated situations in everyday life. Furthermore, role playing was used to apply relaxation training within a context where usually psychologically induced stress leads to increased tremor and deterioration of performance. In this context, the application of relaxation techniques therefore provided a method of negatively reinforcing participation in social interactions. Positive reinforcement was given by the therapists whenever successful relaxation, motor performance, or adequate social behavior was achieved. Specific motor training included training of hand writing, gait, standing up from a chair, and activity schedules. A crucial element in the behavior modification group was the training of initiation and control of movements that patients were no longer able to perform adequately (e.g., starting to walk without a long time delay, turning in bed, getting up, etc.). The training aimed at providing patients with specific strategies, for example the use of external cues and internal commands. These strategies are based on findings that patients with PD benefit from using external and internal cues when performing motor behavior (Bracke-Tolkmitt, 1989; Ludin, 1988). In the first session, patients' motor performance was videotaped and subsequently evaluated by the therapists. Based on these analyses, therapists and patients together defined motor and social problems for each individual. These deficits were approached systematically during subsequent sessions. In addition, progressive muscle relaxation (Jacobson, 1938) was used to provide the patients with a method to voluntarily relax. This was applied when difficult social interactions were practiced during role playing, in particular if patients showed signs of emotional stress reducing their performance. Throughout the behavioral treatments, the therapists followed a manual that defines a behavioral treatment schedule for 20 consecutive sessions (Strehl & Birbaumer, 1996). Every individual session was structured as follows: breathing exercise, evaluation of homework and problems related to homework, behavior modification training (motor and/or social training), new homework, progressive muscle relaxation (20 min).

The *nonspecific psychological treatment* was designed to control for nonspecific therapeutic effects, and included some techniques that were similar to the methods applied in the specific treatment. For example, relaxation was included in both treatments, although only in the behavioral group condition was progressive muscle relaxation training systematically applied to improve performance in social role playing. The major objective of the nonspecific treatment was to discuss problems and to give information about disease-specific problems, but not to practice any motor behavior or to provide patients with specific social strategies. Sessions in the control group were less structured. They included the following elements: breathing exercise, discussion of problems and information about PD, short physical exercises, short relaxation (5 min) by imagination of a pleasing landscape.

Therapists

Both treatment groups were conducted by three clinical psychologists. Therapists' behavior and adherence to the treatment manual was supervised by an independent rater, a psychologist watching all treatment sessions through a one-way window. The therapists' theoretical orientation and training were behavioral. Both for pragmatic reasons and to control for variables such as therapist personality and style, all treatment sessions were conducted by the same three therapists. Each of the therapists had to treat an approximately equal number of experimental and control subjects. Therapists were aware of experimental biases that could be introduced by variations in their behavior. Note that it was not possible to blind therapists to the study's hypotheses, because only three therapists participated in the study and, due to the purpose of the study, they were instructed to apply different treatments in the respective groups.

Cognitive Assessment

Before the treatment several tests were administered to assess possible cognitive impairments and to exclude patients with dementia. They included a reduced version of the WAIS-R (Wechsler, 1981) including the subtests Information, Picture Completion, Similarities, and Block Design, the Wisconsin Card Sorting Test (WCST; Nelson, 1976), and a word fluency test. In the word fluency test, patients had to name as many words as possible starting with the letter B, name as many categories of fruits as possible, and, alternately, name as many animals and words as possible starting with the letter M. Data derived from these tests are summarized in Table 1.

Outcome Measures

For assessment of behavioral (motor and social) changes, a number of subjective rating scales and objective measures were applied. The following measures were used before and after treatment in order to assess treatment outcome (cf, Hypotheses (a) - (c) listed in the Introduction). The examination of patients' neurological status, especially their motor performance, was done by a neurologist using the Unified Parkinson's Disease Rating Scale (UPDRS; Fahn, Elton, & members of the UPDRS Development Committee, 1987). The UPDRS is the most widely used clinical instrument for assessing PD symptoms. It is a semiquantitative clinical rating scale. Its items are grouped into six parts called Motor Examination (14 items); Modified Hoehn and Yahr Staging (1 item); Mentation, Behavior, and Mood (MBM, 4 items); Schwab and England Activities of Daily Living Scale (ADL, 1 item); Activities of Daily Living for on/off States (13 items); and Complications of Therapy (11 items). Out of these six parts, four were administered. Because the motor examination part of the UPDRS is the most relevant clinical measure of motor performance and tremor in PD patients, and because it has a rather high reliability (r = .82; Richards, Marder, Cote, & Mayeux, 1994), it was well suited to be applied as a measure in this study. A decrease of the scores on the UPDRS means that the clinically assessed symptoms have improved. Note that application of a measure of tremor and motor performance is motivated by hypotheses (a) and (b) listed in the Introduction. As another less detailed measure of the severity of the illness, the modified version of the Hoehn and Yahr scale (Hoehn & Yahr, 1967; modified in Fahn et al.) was administered. The clinical diagnosis and estimation of the degree of severity of the disease are usually made on the basis of these examinations. Two other subtests, the Schwab and England ADL Scale and the assessment of mentation, behavior, and mood, were administered in order to control for unspecific treatment effects (see below). Most items of the UPDRS require the neurologist to give ratings on a scale ranging from 0 (normal) to 4 (severe impairment). For example, for the item "tremor at rest" of the motor examination, a score of 0 means absence of tremor and a score of 4 means that the tremor has a marked amplitude and is present most of the time.

In addition to these subtests of the UPDRS, an objective method for determining specific motor impairments, the computer-assisted Motor Performance Test Series (MPS; Schoppe, 1974) by Schuhfried (1987) was applied. This test allows for an exact quantification of the speed and accuracy of complex arm, hand, and finger movements, such as following a winding line with a pencil-like instrument. We preferred this objective measure to EMG recordings because previous results suggest that it is hard to detect changes in the EMG in the course of PD therapy (see discussion above) and because it is difficult to draw conclusions from EMG measures on the success of complex motor performance, while the MPS provides exact measures of accuracy and speed of complex motor performance. The MPS includes four subtests (4 items per hand): Aiming, Line Tracking, Steadiness, and Insertion of Pins. All of these tasks are designed to measure the speed and precision of arm-hand movements (Pinter, 1992). For example, in the Aiming task, patients have to touch 20 small disks with a pin as fast as possible. The diameter of each disk is 1 cm and the distance between any two disks is 1.1 cm. For quantitative analysis, latency and number of hits/misses were obtained. Subjects had to perform all four tasks with either hand. Left and right hand performance was analyzed separately.

To obtain information about the patients' subjective view of possible changes during therapy, a 6-item rating scale was used. After the therapy, patients were asked to rate their subjective improvement of symptoms on scales ranging from 0 (no improvement) to 6 (profound improvement). The following items were included in the rating scale: gait/posture, tremor, manual dexterity, depression, management of critical situations, and behavior in social interactions. The same rating scale was also used by the supervising psychologist as an additional estimation of success of treatment.

Additional tests were used to assess nonspecific consequences of the treatment: a) The neurologist rated the patients' activity level by using the ADL rating scale (Schwab & England, 1969). (This was done to obtain information about whether everyday activities changed during therapy.) b) The Mentation, Behavior, and Mood subtest of the UPDRS was administered primarily to check for possible changes in mood during the therapy period. c) Also for investigating possible mood changes, Beck's Depression Inventory (BDI; Beck, Ward, Mendelsohn, Mock, & Erbaugh, 1961) was applied. (The BDI is a 21-item self-report measure of depression). d) On an assertiveness questionnaire (Ullrich de Muynck & Ullrich, 1977), patients had to rate uneasiness and lack of certainty in social interactions on a 64-item self-report scale. (It was assumed that this measure would provide information about both success in social situations and nonspecific treatment effects.) e) A contentment of life (Herschbach, 1993) questionnaire, a 32-item self-report measure of degree of importance and contentment with family situation, health etc., was administered. (All these examinations (a–e) were administered before and after therapy.) f) A 6-item questionnaire about the patients' expectations and hopes towards the treatment was applied only before the treatment. (This was done to ensure that the two groups did not differ in their expectations.) g) A rating scale was used for assessing patients' anonymous judgment of therapist competence in order to control for potential effects due to therapist-related behavior in both groups. (This scale was administered three times in the course of the treatment interval [in sessions 3, 10, 20]). Patients were asked to rate their general satisfaction and confidence with each of the therapists, the therapists' knowledge of PD, whether therapists accepted the patients' problems, and whether patients would recommend the therapists.)

Assessment and ratings of the dependent measures was done by the supervising psychologist in order to exclude therapist-related influences on outcome measures. The neurological evaluation (UPDRS and MPS) before and after treatment was conducted by a neurologist blind to the hypotheses tested and to group membership.

Statistical Evaluation

In order to test the three hypotheses (see Introduction), both univariate and multivariate analyses of variance were performed on the data obtained. Two-way MANOVAs (Group × PrePost) were calculated for the following tests: the motor examination of UPDRS, the mentation, behavior and mood subscale of the UPDRS, the ADL subscale of the UPDRS, the objective measure of motor performance (i.e., the computerized MPS), and the contentment of life questionnaire (see Table 2, measures 1.1, 1.3, 1.4, 2, and 7). As detailed above, the MPS result includes error scores and reaction times. In order to conduct an overall analysis of the results of this test series, all data were first converted to z-scores (with positive values indicating better performance). Subsequently, these z-scores were subjected to MANOVA.

The other measures were analyzed by ANOVAs and t-tests. For example, the psychologists and the patients' ratings of symptoms (measures 3 and 4 in Table 2) were analyzed by a three-way ANOVA (Group × Rater × Items). In addition, separate analyses were performed for the psychologists' and the patients' ratings, respectively. For BDI (measure 5) and diverse scales of the assertiveness questionnaire (measure 6), separate two-way ANOVAs (Group × PrePost) were run. The patients' expectancies before the therapy (measure 8) were evaluated with a t-test, and the rating of therapists' competence (measure 9) was evaluated in another two-way ANOVA (Group × Sessions [3 levels—recall that 3 ratings were obtained in sessions 3, 10, and 20]).

Results

Possible Selection Bias and Demographic Effects

One-way analyses of variance (ANOVA) were performed on all pretreatment data to verify the random assignment procedure. The analyses revealed no significant differences between the two treatment groups on the clinical and demographic variables (see Table 1). There were no significant differences at pretreatment assessment of all other dependent measures except for performance on the MPS (see Figure 2).

The sizes of the two treatment groups differed between the two therapy approaches. Behavioral treatment was usually administered in groups of 3

TABLE 2

DATA FROM TESTS AND QUESTIONNAIRES APPLIED TO ASSESS TREATMENT-RELATED PERFORMANCE CHANGES AND UNSPECIFIC TREATMENT EFFECTS ARE LISTED FOR BOTH TREATMENT GROUPS BEFORE AND AFTER THE INTERVENTION

	Groups/Treatments							
	BG				CG			
	Pretreatment		Posttreatment		Pretreatment		Posttreatment	
	M	SD	M	SD	M	SD	M	SD
1. UPDRS								
1.1 Motor Examination	1.317	0.920	1.133	0.889	1.193	0.872	1.220	0.887
1.2 Hoehn & Yahr Stage	2.025	0.658	1.900	0.417	2.119	0.350	2.071	0.327
1.3 Mentation. Behavior & Mood	0.775	0.881	0.625	0.603	0.762	0.705	0.738	0.642
1.4 Activities of Daily Living	0.977	0.843	0.855	0.744	0.941	0.770	0.889	0.754
2. Motor Performance Test								
2.1 right hand	0.144	1.248	–0.065	0.890	–0.068	0.918	–0.007	0.875
2.2 left hand	0.042	1.157	0.087	0.912	–0.058	0.941	–0.065	0.952
3. Patients' rating			3.231	1.699			2.296	1.713
4. Psychologist's rating			2.250	1.271			1.301	1.324
5. BDI	9.650	6.055	7.900	4.599	10.524	4.905	8.143	4.396
6. Assertiveness Question								
6.1 Fear of failure	33.350	15.732	35.800	17.884	31.762	11.789	32.905	11.282
6.2 Social phobia	33.050	14.986	33.600	15.578	32.905	14.622	32.286	10.455
6.3 Ability to demand	37.850	7.849	40.900	8.837	37.905	10.658	39.762	10.173
6.4 Ability to refuse	28.850	10.210	29.300	9.745	28.810	7.865	27.952	6.697
6.5 Sense of guilt	8.700	5.469	9.900	5.399	9.238	5.127	8.905	4.346
6.6 Decency	14.600	4.031	14.550	4.186	14.952	3.681	14.286	4.303
7. Contentment of Life								
7.1 General Contentment	3.478	1.200	3.698	1.036	3.411	1.107	3.458	1.060
7.2 Contentment of health	3.031	1.090	3.338	1.021	2.851	0.977	3.143	0.864
8. Treatment Expectations	3.483	1.815			3.190	1.797		
9. Therapist Competence			5.155	1.009		5.186	0.770	

to 4 subjects while groups receiving non-specific psychological treatment included 5 to 7 subjects.

Computation of Outcome Measures

Motor Examination of the UPDRS. The two-way MANOVA, including information about all 14 items of the motor examination, revealed a significant main effect of the factor PrePost (Wilks' Lambda = 0.84, $F(1,39) = 6.9$, $p = 0.01$), indicating better performance after therapy. Most importantly, the interaction of the factors Group × PrePost was highly significant (Wilks' Lambda = 0.75, $F(1,39) = 12.4$, $p < 0.001$). This interaction is displayed in Figure 1. Post hoc ANOVAs revealed no performance change in the control group while the group receiving behavioral treatment revealed significant improvements ($F(1,19) = 6.5$, $p = 0.01$). The factor subtest did not significantly interact with any of the other 2 factors, but separate analyses of results on all 14 items of the motor examination revealed significant Group × PrePost interactions for a measure of rigidity, the items facial expression, $F(1, 39) = 6.8$, $p < 0.01$, two measures of tremor called tremor at rest $F(1, 39) = 7.2$, $p < 0.01$ and action tremor $F(1, 39) = 4.3$, $p < 0.04$, and two items related to motor performance, arising from chair $F(1, 39) = 16.0$, $p < 0.0003$ and body bradykinesia $F(1, 39) = 12.6$, $p < 0.001$. All of these interactions were due to PrePost changes in the behavioral group. This and the lack of a significant

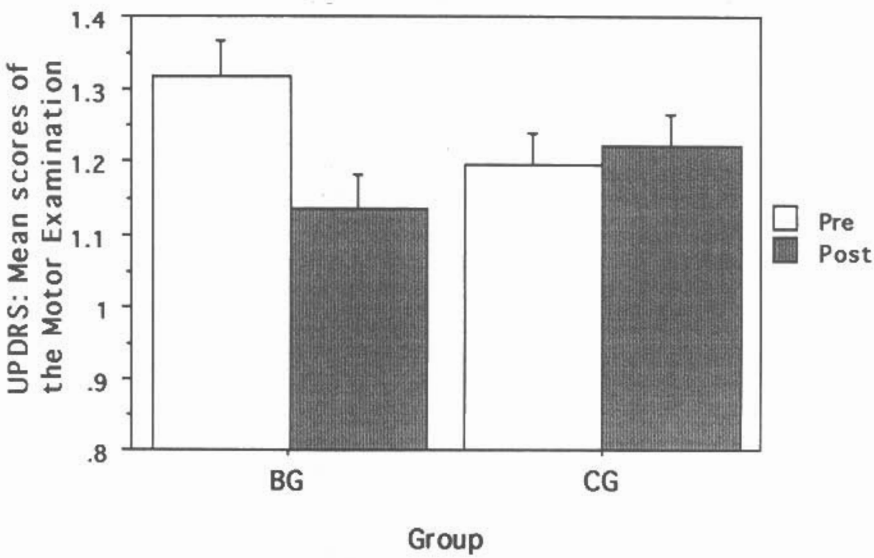

FIG. 1. Results of the *Motor Examination of the UPDRS*. Lower scores indicate better performance. The overall interaction of Group × PrePost is displayed. It indicates improvement in the group receiving behavioral treatment, but no performance changes in the control group.

interaction of the subtest factor indicates that changes were present in the behavioral treatment group throughout the range of PD symptoms (i.e., related to motor performance, tremor, and rigidity).

Modified Hoehn and Yahr Staging. This measure did not reveal any significant change over the treatment interval for any of the groups. However, the mean scores of the behavioral group were 2.03 before treatment and 1.90 thereafter while the mean scores of the controls changed from 2.12 to 2.07. Although, again, this does not constitute a significant difference, it may be interpreted as evidence for a tendency towards stronger improvements in the behavioral treatment group compared to the control group.

Mentation, Behavior, and Mood of the UPDRS. A two-way MANOVA showed a significant main effect of the factor PrePost (Wilks' Lambda = 0.89, $F(1, 39) = 5.0$, $p = 0.03$). Post hoc ANOVAs showed improvements after therapy only in the behavioral group $F(1, 19) = 6.6$, $p = 0.01$.

ADL of the UPDRS. A two-way MANOVA revealed a significant main effect of the factor PrePost (Wilks' Lambda = 0.81, $F(1, 39) = 9.4$, $p = 0.004$) and a marginally significant interaction of the factors Group × PrePost (Wilks' Lambda = 0.93, $F(1, 39) = 3.1$, $p = 0.08$). Post hoc ANOVAs revealed significant improvements after therapy only in the behavioral group $F(1, 19) = 12.9$, $p = 0.001$.

Computerized MPS. A three-way MANOVA (Group × PrePost × Performing Hand) of the data from the objective measure of speed and accuracy of motor movements revealed no reliable main effects and a significant interaction of the factors Group × PrePost × Performing Hand (Wilks' Lambda = 0.83, $F(1, 39) = 8.0$, $p < 0.008$). When right and left hand performance were compared in separate analyses, no reliable interaction was found in the left hand data, but a significant Group × PrePost interaction was present for right hand data (Wilks' Lambda = 0.87, $F(1, 39) = 5.6$, $p = 0.02$). Post hoc ANOVAs showed significant improvements after treatment only in the behavioral group $F(1, 19) = 8.1$, $p = 0.01$. It should be noted that all but 2 of our patients (1 in each therapy group) were right-handed. Thus, it was the dominant hand that showed an improvement over the therapy interval. This improvement was present in the group receiving behavioral treatment, but not in the control group. Figure 2 summarizes the data from right (dominant) hand performance. Note that this interaction indicates between-group differences before onset of the therapy but not thereafter. This complicates the interpretation of the significant interaction (see Discussion section).

Additional analyses were performed to investigate which of the 5 subtests of the MPS led to the most pronounced PrePost changes. These analyses revealed most pronounced changes of right hand performance on the aiming task for which significant Group × PrePost interaction were obtained on two measures, the number of hits, $F(1, 39) = 9.2$, $p = 0.004$ and the latency, $F(1, 39) = 4.5$, $p = 0.04$. For the variable number of hits, post hoc ANOVAs revealed significant improvements in the behavioral group, $F(1, 19) = 6.4$, $p = 0.02$ and a significant deterioration of performance in the controls $F(1,$

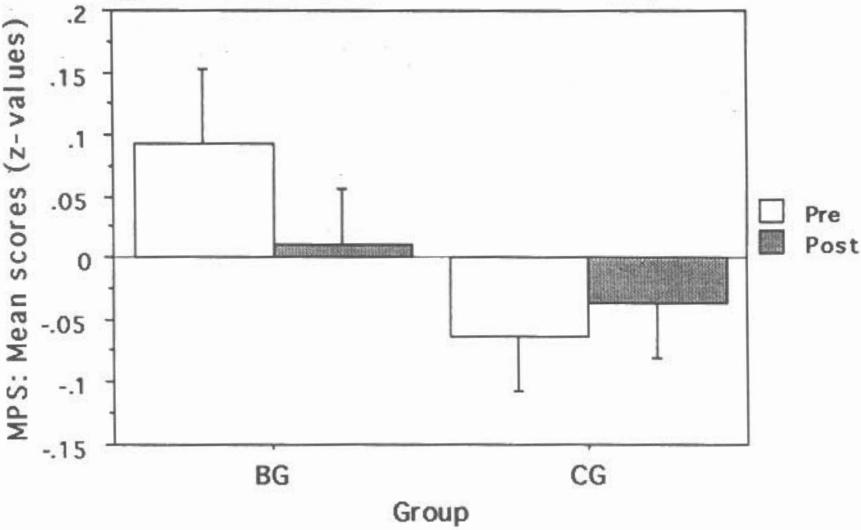

FIG. 2. Results of the computerized *Motor Performance Test Series* (*MPS*). The interaction of the factors Group × PrePost was significant, indicating improvements during therapy only for PD patients receiving behavioral treatment.

19) = 6.3, $p = 0.02$. Post hoc ANOVAs of the latency measure revealed significant improvements only in the behavioral group, $F(1, 19) = 5.2$, $p = 0.03$, while no performance change was observable in the control group.

Patients' and therapists' ratings of changes of symptoms. When all ratings of symptom changes made by patients and the clinician were submitted to an overall three-way ANOVA with the factors Rater (psychologist/patient) × Group × Item, the analysis revealed a significant main effect of the factor Group, $F(1, 39) = 11.7$, $p = 0.001$, showing that patients in the behavioral group profited more from the therapy than did patients in the control group. In addition, a significant Items × Group interaction, $F(5, 195) = 2.8$, GG = 0.7, $p = 0.03$ was obtained. This interaction indicates that the two treatments differentially affected certain items (symptoms). This complex interaction was further investigated by ANOVAs in which psychologists' and patients' ratings were analyzed separately. In both cases, there was a significant main effect of the factor Group: Patients' ratings, $F(1, 39) = 4.8$, $p = 0.03$, psychologist's rating $F(1, 39) = 17.3$, $p = 0.0002$. The psychologist's rating revealed an additional significant Group × Items interaction, $F(5, 195) = 3.0$, $GG = 0.66$, $p = 0.02$. Significant between-group differences were seen in the psychologists' ratings of most of the items. Improvements of gait, tremor, precision movements and social interaction skills were judged to be stronger in subjects from the behavioral group compared to the control group. Only ratings of improvements of tremor, precision movements and critical situations

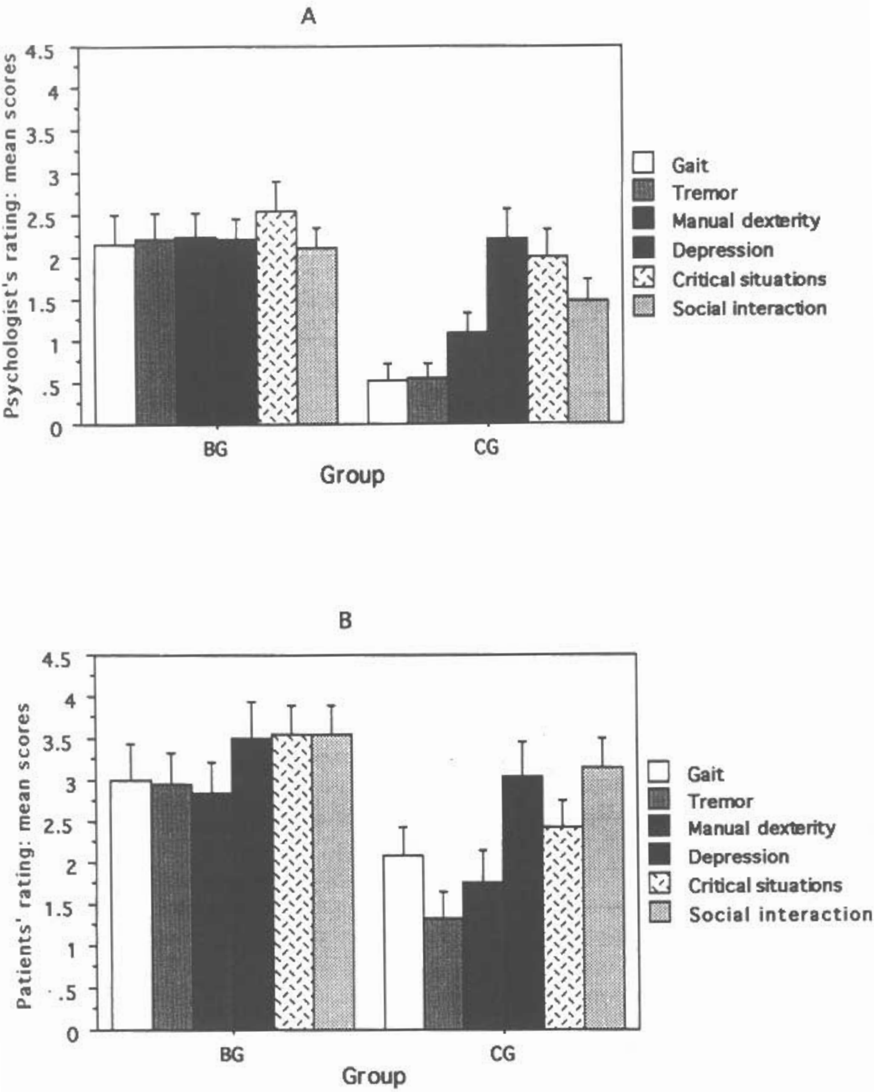

FIG. 3. Results of the psychologist's (A) and patients' (B) *ratings of symptom changes* in the behavioral and the control group. Item 1: gait/posture, Item 2: tremor, Item 3: manual dexterity, Item 4: depression, Item 5: critical situations, Item 6: social interactions. A significant Group × Item interaction was seen in the psychologist's ratings only.

were consistently judged to be stronger in the behavioral group than in the control group. Figure 3 illustrates the psychologist's ratings of performance by experimental and control subjects (Fig. 3a) and the patients' self-ratings (Fig. 3b).

Additional tests and questionnaires. The following measures failed to reveal any significant effects: Schwab and England ADL scale, the assertiveness questionnaire (6), the ratings of pretreatment expectancies (8), and the ratings of therapists' competence (9).

There was some evidence for mood changes over therapy. BDI (5) revealed significant main effects of the factor PrePost due to reduced depression or higher mood scores after therapy. For the BDI, this main effect was highly significant ($F(1,39) = 10.6$, $p < 0.002$), and the effect was also reliable in the data from the MBM and ADL of the UPDRS. These effects are consistent with an improvement of mood and reduction of depression over the therapy interval. Also the questionnaire about contentment of life (7) revealed higher scores after therapy. The main effect of the PrePost factor was highly significant only in the subscale contentment of health (Wilks' Lambda = 0.78, $F(1.39) = 11.9$, $p < 0.001$) and an improvement of contentment was equally apparent in both groups. For an overview, the results of the applied measures are listed in Table 2.

Discussion

Subjective and objective measures of the symptoms of PD revealed significant improvements of symptoms in a group of 20 patients receiving 10 weeks of behavioral treatment, while no such improvement was seen in matched controls receiving nonspecific psychological treatment. Three independent measures revealed that motor performance improved in the group receiving behavioral treatment but not in the control group. The motor examination subtest of the UPDRS and a computerized measure of fine motor movements (MPS) revealed significant interactions of the Group and PrePost factors, indicating specific improvements in the behavioral group. There was also evidence for a reduction of tremor in the behavioral treatment group but not in the control group. This evidence came from results of the motor examination of the UPDRS and from subjective ratings by patients and the supervising psychologist. Furthermore, there were changes equally apparent in both therapy groups. Results of questionnaires indicated that mood changes (reduction of depression) and contentment of life both improved over the 10-week therapy interval.

Improvement of motor performance in the behavioral group was evidenced by an objective measure, the computerized MPS. Most pronounced between-group differences were seen in the results of the aiming task of the MPS, where both error scores and response times revealed improvements in the behavioral group but not in the control group. It is well established that performance on the MPS highly correlates with motor performance relevant in everyday life, such as handwriting or cutting with a knife (Pinter, 1992). However, the observed interaction revealed by MPS data is subject to the following qualification. There was a significant between-group difference before onset of therapy (see Fig. 2). Note that patients of the two groups were shown to be similar for a variety of variables including clinical, psychological, and demographic data. When using a large number of measures (as in the present study), there is a high probability that patients will differ by chance on one of them. Nevertheless, it could be argued that the significant Group × PrePost interaction may reflect a regression towards the mean in the experimental group. However, it seems unlikely that regression toward the mean would take place in so many different measures and only in the experimental group. Therefore, there is strong evidence from three independent measures that behavioral treatment can indeed lead to improvement of motor abilities in patients with PD.

There is also some evidence for an improvement of tremor related to behavioral treatment. The clinical assessment of tremor based on UPDRS (tremor at rest and action tremor items) revealed improvements in the behavioral group only. In addition, patients' and therapists' subjective ratings of tremor reduction during therapy were higher for the behavioral treatment group compared to the control group. Thus, clinical measures as well as subjective ratings suggest an improvement of tremor related to behavioral therapy.

Patients in both groups had a relatively high estimated Full Scale IQ (mean IQ in each group was 116) compared to an average population. This is possibly due to two reasons. First, only mildly to moderately impaired patients without intellectual impairments were included in this study. Second, only volunteers were participating in the study and this may have led to a bias towards a cognitively more flexible sample. However, it appears likely that patients with lower Full Scale IQs will also benefit from behavioral PD therapy.

Numerous measures were applied in order to assess the general effects of receiving any treatment. All these examinations failed to reveal any significant between-group differences. Patients' ratings on measures of depression and mood (MBM and ADL subtests of the UPDRS and BDI) revealed improvements of mood in both groups. The same applies for the ratings of contentment of life. All other measures of ADL (Schwab & England, 1969), assertiveness, and expectancies did not reveal any significant effects. While none of these measures revealed between-group differences, most of the tests and examinations related to our main hypotheses showed clear differences between the groups. It is, therefore, likely that the performance changes seen in the experimental group represent true effects of the behavioral therapy.

The slightly different number of patients per treatment group may have led to more personal attention from the therapists in the experimental group, because these groups were smaller, and some of the therapy effects observed may be due to this. The possibility of this kind of bias cannot completely be excluded, but there are arguments against it. In both groups, there were equivalent judgments of therapist competence, suggesting that participants in both groups viewed their therapy positively. However, additional time was necessary in this treatment due to the motor training, which is extremely time consuming. Since patients had to practice on their own and were given positive reinforcement only after successful performance, interactions were frequently interrupted by practice during behavioral treatment but not in the control groups. Overall, it is estimated that the average time patients spent during

Improvements of motor performance and tremor were seen in PD patients treated with the behavioral training program. The neurological substrates of these behavioral changes are unknown. However, there is reason to believe that an increase in use of (motor) neurons can slow down the neuronal degeneration seen in PD. Taub and co-workers (Taub, Perrella, & Barro, 1973) have shown that learned suppression of movements in monkeys after differentiation and in humans suffering from acute stroke is another relevant factor for the reduction of neurophysiological functioning and motor abilities. Taub and his colleagues could even show that behavioral training of acute stroke patients, which forced them to use the extremities affected by the stroke, led to improvements of motor abilities (Taub et al., 1994). These and other data support the view that what Taub calls *learned nonuse* is an important factor in the reduction of nervous functioning and motor abilities in neurological diseases. From this perspective, it is possible that learned nonuse also plays an important role in the progression of PD. In this case, behavioral treatment would be an important method for overcoming learned nonuse and its negative effects. The present behavioral treatment may, therefore, improve the patients' conditions by saving them from additional neuronal degeneration caused by learned nonuse. In order to test this, additional therapy studies will have to be conducted that monitor PD patients' symptoms over longer intervals in order to investigate whether treatment-related performance changes occur only at the beginning and during the first weeks of therapy, or whether decline of performance can be reduced over longer intervals (months to years). In addition, direct measurement (i.e., PET or functional MRI) of dopaminergic function in the nigro-striatal system before and after behavioral treatment could reveal neurochemical correlates of improved motor functioning.

In conclusion, the results of this study indicate that training of motor and social skills using behavioral techniques is an important supplement to traditional treatment with L-Dopa. Motor impairments in PD, such as tremor or impaired manual dexterity, can be improved by the application of a specific behavioral training. It was also demonstrated that a nonspecific psychological treatment was not effective in reducing symptoms of PD. Although there is now some evidence that behavioral training can lead to symptom improvement in PD, further research is necessary for investigating whether behavioral treatment can reduce the decline of performance over longer therapy intervals.

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