Active Music Therapy in Parkinson's Disease: An Integrative Method for Motor and Emotional Rehabilitation

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Background: Modern management of Parkinson's disease (PD) aims to obtain symptom control, to reduce clinical disability, and to improve quality of life. Music acts as a specific stimulus to obtain motor and emotional responses by combining movement and stimulation of different sensory pathways. We explored the efficacy of active music therapy (MT) on motor and emotional functions in patients with PD. **Methods:** This prospective, randomized, controlled, single-blinded study lasted 3 months. It consisted of weekly sessions of MT and physical therapy (PT). Thirty-two patients with PD, all stable responders to levodopa and in Hoehn and Yahr stage 2 or 3, were randomly assigned to two groups of 16 patients each. We assessed severity of PD with the Unified Parkinson's Disease Rating Scale, emotional functions with the Happiness Measure, and quality of life using the Parkinson's Disease Quality of Life Questionnaire. MT sessions consisted of choral singing, voice exercise, rhythmic and free body movements, and active music involving collective invention. PT sessions included a series of passive stretching exercises, specific motor tasks, and strategies to improve balance and gait. **Results:** MT had a significant overall effect on bradykinesia as measured by the Unified Parkinson's Disease Rating Scale ($p < .034$). Post–MT session findings were consistent with motor improvement, especially in bradykinesia items ($p < .0001$). Over time, changes on the Happiness Measure confirmed a beneficial effect of MT on emotional functions ($p < .0001$). Improvements in activities of daily living and in quality of life were also documented in the MT group ($p < .0001$). PT improved rigidity ($p < .0001$). **Conclusions:** MT is effective on motor, affective, and behavioral functions. We propose active MT as a new method for inclusion in PD rehabilitation programs. **Key words:** music therapy, Parkinson's disease, rehabilitation.

ADL = activities of daily living; ANOVA = analysis of variance; HM = Happiness Measure; MS = motor subscale; MT = music therapy; PD = Parkinson's disease; PDQL = Parkinson's Disease Quality of Life Questionnaire; PT = physical therapy; UPDRS = Unified Parkinson's Disease Rating Scale.

INTRODUCTION

Modern management of PD as well as efforts to obtain better symptom control are directed toward recovering the patient's functional status, thus improving both clinical disability and quality of life (1–4). To achieve global improvement in personal well-being, drugs, in accordance with standard guidelines, as well as interdisciplinary measures, such as physical exercise, occupational and speech therapy, and psychological, nutritional, and social counseling, have been used(5–7). We explored MT as a method for inclusion in PD rehabilitation programs. Even though MT is widely used in a variety of settings, including hospitals, rehabilitation centers, special schools, and hospices (8, 9), the literature contains few assessments of MT in medical care. Music has been used as a form of therapy for many different diseases and, unless hearing is totally affected, may indeed be experienced and appreciated by even the most severely physically or cognitively impaired subjects (10). MT has been widely used in the rehabilitation of handicapped children, providing one of the few ways in which these subjects can attain self-expression (11). In addition, MT is recommended in geriatric care to improve the social, psychological, intellectual, and cognitive performance of older people (12, 13). Depressed older adults, in particular, can experience the effects of passive MT (14, 15). MT reduces anxiety in patients undergoing cardiac procedures throughout the perioperative period and in those who have had a myocardial infarction (16, 17); moreover, music seems to relax patients undergoing surgery (18) or invasive diagnostic procedures (19). It has also been suggested that music may modify release of stress hormones and cardiac function (20) as well as the respiratory pattern (21). Finally, anecdotal evidence and clinical studies show that MT improves the cognitive functions and quality of life of patients with Alzheimer's disease (22–24).

There are two main branches of MT, active and passive. In brief, active MT is based on the improvisation of music by the therapist and patients, who play an active part by using instruments and voice. The use of instruments is structured to involve all the sensory organs; the rhythmic and melodic components of music may be used as specific stimuli to obtain certain

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motor and emotional responses, thus combining movement and stimulation of different sensory pathways, that is, auditory and tactile (multiple sensory stimulation), with a well-established emotional quality. Passive MT is conducted with the patient at rest. With the aim of producing a state of mental relaxation, the therapist plays calming music and invites the patient to visualize peaceful images.

PD is a common degenerative disease dominated by a disorder of movement, consisting of bradykinesia (slowness of movement), hypokinesia (reduced movements), tremor, rigidity, and postural and gait abnormalities; mood changes are also a major component of PD (6).

In view of the features of the disease, application of active MT would seem to be appropriate in PD, even though there are, so far, no objective reports on the efficacy of this kind of therapy in patients with PD. The first aim of this study was to verify the efficacy of MT on motor involvement in patients with PD. Moreover, given that PT is the main nonpharmacologic course of intervention in PD (25), we conducted a randomized, controlled, single-blinded, prospective study comparing PT with MT. In addition to measuring clinical changes, we evaluated the influence of these two types of therapy on both the emotional well-being and quality of life of PD patients.

METHODS

Subjects

Thirty-two PD outpatients were invited to participate in the study, and informed consent was obtained. To meet our selection criteria, patients had to have idiopathic PD and had to be responsive to levodopa therapy or other dopaminergic treatments. Patients with secondary parkinsonism (ie, due to vascular disease, drugs, infections, toxicity, or other conditions) were excluded. Patients were stable responders or early fluctuators to levodopa, in Hoehn and Yahr stage 2 or 3, and not affected by cognitive deterioration, severe sensory (visual or auditory) deficits, or diseases affecting movement.

Patients were allowed to continue taking their medication, but the dosage had to have been constant for 1 month before the trial and had to remain constant throughout the entire study period. Dopaminergic therapy consisted of levodopa (standard and slow-release formulations) alone or in association with dopamine agonists, such as pergolide or bromocriptine. Sixteen patients (12 men and 4 women; mean age, 62.4 years; mean duration of illness, 4.8 years) took part in weekly sessions of MT, and 16 patients (11 men and 5 women; mean age, 63.1 years; mean duration of illness, 5.2 years) had weekly sessions of traditional PT. Patients were randomly assigned to these groups by using a computer-generated number list. The groups were similar in age, time since diagnosis, drug schedules, duration and severity of illness, and motor impairment and disability, as measured by the MS and ADL subscales of the UPDRS, respectively (26). Furthermore, no significant differences in emotional functions, as assessed by the HM (27), or quality of life, as measured by the PDQL (4), emerged between the groups (Table 1).

TABLE 1. Characteristics of Study Population

	Group	
	MT	PT
No. of patients	16	16
Gender		
Male	12	11
Female	4	5
Mean age, (SD), years	62.5 (5)	63.2 (5)
Mean duration of illness (SD), years	4.8 (3)	5.2 (2)
Mean dosage (SD), mg/day, and no. of patients		
Levodopa alone	583 (189), 3	540 (148), 5
Levodopa in association with other drugs	596 (116), 13	591 (113), 11
Pergolide	2 (1), 9	2 (1), 6
Bromocryptine	14 (5), 4	12 (5), 5
Mean score (SD)		
UPDRS-MS	40.2 (7.7)	40.7 (7)
UPDRS-ADL	21.7 (4)	21.7 (5.5)
HM combination	42.6 (15.6)	41.7 (13.7)
HM part 1	5 (1.7)	5.3 (1.3)
PDQL	114 (3.5)	115.2 (2.6)

Study Design

This prospective, randomized, controlled study lasted 3 months. Patient examinations were conducted 1 hour before the start of the PT or MT session by a neurologist (C.P.), blinded to the patient's study group, after the first morning dose of therapy. Postsession examinations were conducted within 1 hour after conclusion of the session, before the second drug was taken. The UPDRS motor examination (score range, 0–108) was administered to all patients at weeks 1, 3, 5, 7, 9, and 11 of the study and at the follow-up examination, which was conducted 2 months after completion of the study. The patient's emotional state was assessed at the same time as motor function, using the short, self-administered HM, which was filled in by the patient. In brief, the HM consists of two self-report questionnaires (parts 1 and 2) that measure emotional well-being. Part 1 examines the intensity (or quality) of happiness (ie, how happy or unhappy one feels, with 10 = extremely happy and 0 = extremely unhappy) and part 2 measures the frequency (or quantity) of happiness (ie, the percentage of time one feels happy, unhappy, or neutral) during the past month. Another parameter considered was the combination score, calculated as follows: (Happiness Intensity $\times$ 10 $-$ Happiness Frequency)/2, which combines the two scores in equal weights. The combination score was assessed at weeks 1, 5, 9, and 11 and at the follow-up visit. Validity studies have revealed a marked inverse relationship between the HM and indices of unhappiness usually used to assess mood disorders in patients with PD, such as the Beck Depression Inventory (27, 28). Each patient completed the PDQL at baseline, midway through the study, the end of the study, and 2 months after study completion (follow-up visit). Items on the PDQL explore the severity of illness in addition to systemic, social, and emotional variables (score range, 37–185). At the same time, changes in ADL were evaluated in each patient (score range, 0–24).

The 16 patients of the PT group, divided into two groups of 8, attended weekly sessions, each lasting about 1.5 hours. PT consisted of a series of passive muscle stretching exercises for rigidity and joint mobility, specific motor tasks for hypokinesia, weight shifting and balance training for posture, plus movement strategies to pre-

vent falls and to initiate and maintain gait (29, 30). During the PT sessions, patients performed the exercises concurrently but individually, with minimal interaction with one another.

The 16 MT patients were divided into two groups of 8, which is considered the ideal number of subjects to participate in a group session. Each group took part in 13 weekly sessions of active MT lasting about 2 hours each. Active MT involves improvisation by the therapist, who invites patients to play an active role using instruments and voice. Patients do not require any musical training. Each session was conducted by a music therapist who played an active part in the proceedings.

Sessions were subdivided into standard sections as follows: entrance and interview, 10 minutes; listening to relaxing music and visualization of images, 10 minutes; choral singing and facial expression, breathing, and voice exercises, 15 to 20 minutes; rhythmic movements (eg, involving lower limbs, upper limbs, and gait), 30 minutes; active music involving collective invention and improvisation, 30 to 40 minutes; free body expression to melodic and rhythmic music, 20 to 30 minutes; and conversation, 10 minutes. Patients used all instruments at their disposal, adopting a free technique. The equipment consisted of a piano, organ, percussion instruments (eg, metallophones, xylophones, drums, wood blocks, and cymbals), and a high-fidelity system. In MT sessions, exercises were performed by couples, small groups, or even the group as a whole with a high level of interaction and communication within the group (eg, patients performed rhythmic or melodic improvisation using instruments and voice freely, or, in another exercise, some of the patients played the wood blocks with an alternating movement of the arms while the rest of the group marched to the rhythm). Our methods are extensively described elsewhere (31).

Statistical Analysis

We used Friedman's to compare paired data emerging from the evaluation of all presession scores (overall evaluation), within MT and PT groups, of the following measures: UPDRS-MS, UPDRS-MS factors (ie, bradykinesia, rigidity, and postural and resting tremor) (32, 33), UPDRS-ADL, HM (combination and part 1 scores), and PDQL (total and partial scores). The bradykinesia factor was the summation of the following items: speech, facial expression, rising from a chair, posture, gait, postural stability, body bradykinesia, and limb bradykinesia (right and left hands and feet; score range, 0–68). The rigidity factor (range, 0–20) was the sum of rigidity scores of all extremities and neck, and the rest tremor factor (range, 0–20) was the sum of the tremor score for right and left sides and head. The postural/action tremor score (range, 0–16) was the score for postural or action tremor for the upper extremities (32, 33).

The Wilcoxon signed-rank test was used to compare every week presession and postsession scores on the following measures: UPDRS-MS, UPDRS-MS factors (bradykinesia, rigidity, and postural and resting tremor), and HM part 1. To compare presession and postsession differences between the PT and MT groups every week, we performed the Mann-Whitney *U* test on the following measures: UPDRS-MS, UPDRS-MS factors (bradykinesia, rigidity, and postural and resting tremor), and HM part 1. UPDRS-ADL, PDQL (total and partial), and HM combination scores of the PT and MT groups were compared at weeks 1, 7, and 11 and at the follow-up examination. All statistical tests were two-tailed at the .05 significance level. All statistical analyses were performed with SPSS/PC+, version 4.0.1 for DOS.

RESULTS

The difference between MT pretest and posttest values demonstrated a significant improvement in UPDRS-MS scores (Wilcoxon test, $p < .0001$; Table 2), especially with regard to bradykinesia (Wilcoxon test, $p < .0001$; Table 3). The difference between PT pretest and posttest UPDRS-MS and bradykinesia values was not significant (Tables 2 and 3). Analysis of changes in bradykinesia revealed that MT had a significant overall effect (Friedman's ANOVA, $p < .034$; Table 3). This effect was lacking in the PT group (Table 3). The final evaluation, conducted 2 months after completion of the study, demonstrated a lack of motor benefit with MT. The over-time analysis of rigidity, like the pretest and posttest evaluations, consistently revealed the efficacy of PT training on this factor (Table 4).

A comparison of pretest and posttest differences (Δ)

TABLE 2. UPDRS-MS Results

Time of Evaluation (week)	Mean Score (SD)						Comparison
	MT Group			PT Group			
	Presession	Postsession	p^a	Presession	Postsession	p^a	p^b
1	40.2 (7.7)	27 (6)	<.0001	40.7 (7)	36.6 (6.7)	NS	<.0001
3	38.7 (7)	25.9 (6)	<.0001	40.2 (6.8)	37.5 (6.7)	NS	<.0001
5	39.4 (7.2)	25.2 (6)	<.0001	41.1 (6.2)	37.8 (7)	NS	<.0001
7	38.6 (8)	25.5 (5.8)	<.0001	39.3 (6.2)	37 (5.8)	NS	<.0001
9	38.3 (7.3)	24.7 (5.8)	<.0001	38.5 (6.7)	41.6 (6)	NS	<.0001
11	36.3 (6.2)	24.3 (5.2)	<.0001	41.1 (5.7)	39.3 (5.4)	NS	<.0001
Follow-up visit (2 months)	40.9 (8)			41 (7)			NS
Overall evaluation[c]							
At end of study			NS			NS	
At follow-up visit			NS			NS	

[a] Wilcoxon signed-rank test for presession/postsession analysis. NS = not significant.
[b] Mann-Whitney *U* test for comparison of pretest and posttest differences (Δ) in MS scores between the MT and PT groups.
[c] Friedman's test for overall evaluation.

TABLE 3. UPDRS-MS Bradykinesia Factor Results

Time of Evaluation (week)	Mean Score (SD)						Comparison
	MT Group			PT Group			
	Presession	Postsession	p^a	Presession	Postsession	p^a	p^b
1	28.2 (7.4)	17.3 (5.4)	<.0001	28.6 (6.5)	29 (6.4)	NS	<.0001
3	26.4 (6.3)	17.1 (5.8)	<.0001	29.1 (6.3)	29.3 (6)	NS	<.0001
5	27.5 (6.2)	17.3 (4.7)	<.0001	30.0 (6)	30 (6)	NS	<.0001
7	26.6 (6.8)	17.1 (5.4)	<.0001	30.1 (6.4)	30.3 (6.3)	NS	<.0001
9	26.3 (6.3)	17.4 (5.2)	<.0001	30.2 (7)	32.5 (6.7)	NS	<.0001
11	25 (6.2)	15.5 (5.3)	<.0001	31.9 (6)	31.8 (6)	NS	<.0001
Follow-up visit (2 months)	28.6 (7.6)			28.8 (6.1)			NS
Overall evaluation[c]							
At end of study			.034			NS	
At follow-up visit			NS			NS	

[a] Wilcoxon signed-rank test for presession/postsession analysis. NS = not significant.
[b] Mann-Whitney *U* test for comparison of pretest and posttest differences (Δ) in bradykinesia scores between the MT and PT groups.
[c] Friedman's test for overall evaluation.

TABLE 4. UPDRS-MS Rigidity Factor Results

Time of Evaluation (week)	Mean Score (SD)						Comparison
	MT Group			PT Group			
	Presession	Postsession	p^a	Presession	Postsession	p^a	p^b
1	9 (1.9)	8.8 (2)	NS	9 (1.6)	4.8 (1.4)	<.0004	<.001
3	8.6 (1.5)	8 (1.5)	NS	8.4 (1.2)	4.6 (1.1)	<.0004	<.001
5	8.8 (1.5)	6.2 (1.6)	<.0004	8.5 (1)	4.5 (1)	<.0004	<.001
7	8.8 (1.7)	8 (1.6)	NS	7 (1)	4.5 (1)	<.0004	<.001
9	8.3 (2)	7.4 (1)	NS	6 (1)	4.2 (1)	<.0007	<.001
11	8.4 (1.4)	7.5 (1)	NS	5.4 (1)	3.8 (0.5)	<.0007	<.001
Follow-up visit (2 months)	9.1 (1.5)			9 (1)			NS
Overall evaluation[c]							
At end of study			NS			<.0001	
At follow-up visit			NS			NS	

[a] Wilcoxon signed-rank test for presession/postsession analysis. NS = not significant.
[b] Mann-Whitney *U* test for comparison of pretest and posttest differences (Δ) in rigidity scores between the MT and PT groups.
[c] Friedman's test for overall evaluation.

in the UPDRS-MS score (Table 2) and bradykinesia factor (Table 3) values between the MT and PT groups revealed a statistically significant effect of MT on these parameters (Mann-Whitney *U* test, $p < .0001$), whereas analysis of the rigidity factor revealed that PT rather than MT seems to be efficacious on this factor (Mann-Whitney *U* test, $p < .001$; Table 4).

Analysis of the resting and postural tremor scores did not reveal any significant changes (data not shown).

Variations in the ADL total score demonstrated that MT induced an overall effect on daily performance of activities (Friedman's ANOVA, $p < .0001$; Table 5). Separate analysis of ADL items revealed significant changes in the following activities: cutting food, dressing, falling (Friedman's ANOVA, $p < .0001$), and freezing (Friedman's ANOVA, $p < .05$; data not shown). These results were also confirmed by a comparison of

TABLE 5. UPDRS-ADL (Total Score) Results

Time of Evaluation (week)	Mean Score (SD)		
	MT Group	PT Group	p^a
1	21.7 (4)	21.7 (5.5)	NS
7	16.7 (3.5)	21 (5)	<.0001
11	14.7 (3.6)	21.3 (6)	<.0001
Follow-up visit (2 months)	20.5 (4)	21.5 (5.8)	NS
Overall evaluation[b]			
At end of study	<.0001	NS	
At follow-up visit	NS	NS	

[a] Mann-Whitney *U* test. NS = not significant.
[b] Friedman's test for overall evaluation.

the influence of MT and PT on ADL score changes, which revealed that only MT had an effect on the ADL total score (Mann-Whitney *U* test, $p < .0001$; Table 5).

Changes in emotional functions, as indicated by HM part 1 and combination scores (data not shown for the last), showed marked improvement in the MT group throughout the therapy period (overall effect), thus revealing a beneficial effect of MT on emotional well-being (Friedman's ANOVA, $p < .0001$; Table 6). Presession and postsession changes in HM part 1 scores revealed the capacity of MT to modify emotional functions (Wilcoxon test, $p < .0005$; Table 6). Like motor changes, emotional changes were no longer evident 2 months after completion of MT. Emotional functioning was not modified in the PT group (Table 6). This result also emerges from the comparative analysis of the effect of MT and PT on HM part 1 and combination scores. These findings revealed a significant difference in favor of MT both over the study time and after each session (Mann-Whitney *U* test, $p < .0001$).

Patients participating in MT sessions displayed a considerable improvement in quality of life, as indicated by the PDQL total score (Table 7), due particularly to variations in the emotional ($p < .0001$) and social ($p < .0001$) functioning scores, despite no change in parkinsonian and systemic functioning (data not shown). As seen with the changes in motor and emotional functions, the improvement in the quality of life was no longer evident 2 months after completion of MT. A comparison of differences in the PDQL total and partial scores (data not shown) between the MT and PT groups revealed a major efficacy of MT on quality of life (Mann-Whitney *U* test, $p < .0001$; Table 7).

At the final interview, all MT patients (as opposed to only four PT patients) reported feelings of well-being and dynamism at home, saying that they were more active and keeping themselves busy. In particular, they said they appreciated the social contact and creative means of communication that MT offered them.

TABLE 7. PDQL (Total Score) Results

Time of Evaluation (week)	Mean Score (SD)		
	MT Group	PT Group	p^a
1	114 (3.5)	115.2 (2.6)	NS
7	126.7 (2.7)	115 (2.9)	<.0001
11	132.3 (2.9)	116.5 (5.5)	<.0001
Follow-up visit (2 months)	114.7 (3.9)	115.8 (2.2)	NS
Overall evaluation[b]			
At end of study	<.0001	NS	
At follow-up visit	NS	NS	

[a] Mann-Whitney *U* test. NS = not significant.
[b] Friedman's test for overall evaluation.

DISCUSSION

Suggestions that music improves rhythmic limb movements, gait, and freezing in patients with PD are not new in the clinical literature, even though they are rather scarce (34–36). This study is the first to assess objectively the effect of a systematic program of active MT on standardized measures of PD severity using a prospective, single-blinded design. Moreover, this randomized, controlled clinical study compared the efficacy of MT and PT to highlight any eventual difference between the two methods in their effect on both physical and emotional functions. Our results demonstrate improvements in motor abilities and emotional status

TABLE 6. HM Part 1 Results

Time of Evaluation (week)	Mean Score (SD)						Comparison
	MT Group			PT Group			
	Presession	Postsession	p^a	Presession	Postsession	p^a	p^b
1	5 (1.7)	6.6 (1.7)	<.0001	5.3 (1.3)	5.5 (1.3)	NS	<.0001
3	5.8 (1.2)	7 (0.8)	<.0002	5.5 (1.2)	5.4 (1)	NS	<.0001
5	6.5 (0.8)	7.7 (0.9)	<.0001	5.3 (0.8)	5.2 (1.3)	NS	<.0001
7	6.8 (1)	7.9 (0.7)	<.0005	5.8 (1)	5.3 (0.9)	NS	<.0001
9	7 (0.8)	8.3 (0.6)	<.0002	5.3 (1.2)	5 (1.1)	NS	<.0001
11	7.2 (0.6)	8.3 (0.6)	<.0005	5.4 (0.9)	5.5 (0.7)	NS	<.0001
Follow-up visit (2 months)	5.5 (1.5)			5.6 (1.2)			NS
Overall evaluation[c]							
At end of study			<.0001			NS	
At follow-up visit			NS			NS	

[a] Wilcoxon signed-rank test for presession/postsession analysis. NS = not significant.
[b] Mann-Whitney *U* test for comparison of pretest and posttest differences (Δ) in HM part 1 scores between the MT and PT groups.
[c] Friedman's test for overall evaluation.

related to active MT. The improvement in motor performance was related mainly to changes in bradykinesia. Although the MT-related motor response seemed to decline after each session, a trend of improvement was observed in the MT group in the overall evaluation. Improvement in emotional functions was found both after each MT session and throughout the entire study period, but when measured 2 months after completion of MT, the values returned to baseline levels. Significant improvements in ADL and quality of life were also documented in patients undergoing MT. PT, meanwhile, led to a clear improvement in rigidity but did not induce any major changes in other variables.

Physical rehabilitation has been found to be effective in patients with PD, although the evidence is questionable in some reports (29, 33, 37–39). Generally, PT serves as reinforcement of the motor program, but this kind of intervention is usually lacking in the motivational and emotional spheres, which could explain why traditional PT has little influence on mood state and why it is not easily incorporated into the patient's lifestyle (33). It is well known, on the other hand, that psychosocial variables, such as emotional state or psychosocial stress, strongly influence abnormalities in gait and posture and other motor performances (40, 41). In accordance with such observations, occupational and behavioral therapies based on psychological and motivational aspects can induce improvements in movement initiation and quality (42).

The beneficial effect on emotional variables measured in the MT group may be explained by the different emotional impact that MT has on patients, which is related to its high level of sensory stimulation and high degree of personal interaction. In line with this view, our study suggests a connection between emotions and the facilitation of movement.

In accordance with the clinical literature, it may be argued that the MT-induced improvement in bradykinesia could be due to the effect of external rhythmic cues, which, acting as a timekeeper, may stabilize the internal rhythm formation process in patients with PD (43–45). Indeed, it has been demonstrated that the initiation and execution times in sequential button-pressing tasks are positively influenced by acoustic cues (46), as are gait velocity, cadence, and stride length (47, 48). Along with the rhythmic aspect of music, another factor possibly involved in motor improvement is the affective arousal effect of music, which could influence both motivational and emotional processing. We hypothesize that the variable improvement in bradykinesia may be due to activation of the emotional neural-based network that involves the dopaminergic mesolimbic projections to the ventral striatum-intraccumbens nuclei, the circuit that is assumed to regulate motivational-incentive reinforcements of general behavior (49, 50). Following this view, the motor facilitation in response to MT could be based on emotional reactions momentarily activating the cortical-basal ganglia motor loop, the circuit primarily affected in PD. The behavioral evidence of a functional interface between the limbic and motor systems (51, 52) and the anatomical-functional sensorimotor integration of basal ganglia and cortical frontal regions (52–59) further support this suggestion.

Current knowledge of the cerebral structures involved in the perception of music is derived from clinical-pathological studies and from pioneering positron emission tomographic research (60–62). Listening to music seems to involve distinct neural processes that correspond to the basic components of music, such as rhythm, pitch, and timbre, or even to lexicosemantic access to melodic representations (62), functions that involve one or both hemispheres. Music has been shown to relax and reduce anxiety, modifying release of stress hormones, cardiac function (20), and respiratory pattern (21). These changes induced by music could be at the origin of positive findings in emotional and social items: A clear improvement in the PDQL scale score demonstrates the efficacy of MT on PD patients' quality of life. This improvement emphasizes an important effect of active MT in PD: It promotes socialization, involvement with the environment, expression of feelings, awareness, and responsiveness. MT, in fact, increases motivation in patients whose personality is characterized by the absence of "novelty-seeking" aspects of behavior (63) and by "anhedonia," a mood state characterized by the "loss of internally generated anticipation, motivation, and drive" (49, 50).

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