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Stimulating music increases motor coordination in patients afflicted with Morbus Parkinson[☆]

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Abstract

The present study measured the short-term effect of special stimulating music on motor coordination in Parkinson patients. Eleven patients with a dominant akinetic Parkinson syndrome as well as ten healthy persons (age-matched control group) participated in this study. In the Parkinson group, the measurement of fine motor coordination with the 'Vienna Test System' showed an improvement in two (aiming, line tracking) of the four subtests after listening to the music. The patients improved their performance with the right arm significantly in the subtest aiming-error-time. No statistical differences were found in the other two subtests (steadiness, tapping) in both groups. There was also no improvement in frequency of tapping movement on the power-force-working-plate. Accordingly, music effects more the precision of a movement than the speediness. The measurements on the power-force-working-plate showed a significant improvement in two of five measured parameters: contact time, variability coefficient for total step and impact maximum changed significantly. This study gives evidence that specific music can improve the precision of arm and finger movements.

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Keywords: Morbus Parkinson; Stimulating music; Motor coordination; Motor activity

Parkinson disease (PD) is not fatal, but it impairs the quality of life and may sometimes lead to severe incapacity within 10–20 years. PD is sometimes categorised as either tremor predominant or postural instability and gait disturbed (PIGD). Some studies have suggested that early PIGD symptoms predict a faster decline than having tremor predominant. Treatments are increasingly effective however in alleviating symptoms and even slowing progression of the disease. Nearly all drugs used for PD have strong side effects that cause neurological and psychiatric disturbances.

The aim of this study is to show if stimulating music has an influence on motor coordination in patients afflicted with Morbus Parkinson.

The therapeutic use of music is a field of research which

is of growing interest [7]. Music has been shown to help people move and to get out of bed in the morning. To help the patient enact a specific physiological movement, such as walking music must evoke a response. Some patients report that wearing a walkman and turning music on in situations associated with freezing, such as crossing a street, is helpful. In order to move physically, the rhythm must be stimulating and the music familiar enough to allow for carry-over outside the music therapy session [15,16]. Some studies deal with the theoretical explanation of metronome stimulation effectiveness in patients with PD [3]. Particular elements of music have a specific effect on motor systems. After 3 weeks, the patients with PD demonstrated longer stride length and improved gait velocity by an average of 25% [16]. These data validate the effectiveness of auditory rhythm to improve gait through the rhythmic coupling of auditory and motor systems [16]. Most research is done with rhythmic auditory stimulation in gait training for patients with PD [5,6,8,9,16]. It is also shown that special music elevates significantly the dopamine levels and other neurotransmitters in avian brain [1,2]. Sad and happy mood music showed significant increase in signal intensity in the left amygdala [10,11].

Abbreviations: MPS, motor performance series; AMTI, Advanced Mechanical Technology, Inc; STAI, state trait anxiety inventory; PIGD, postural instability and gait disturbed; PP, Parkinson patients; PD, Parkinson disease; vc, variability coefficient.

[☆] In honor of Manfred Zimmermann on his 70th birthday.

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Eleven male patients with a dominant akinetic Parkinson syndrome and ten males without neurological disorders (control group) were included in the analysis. The patients were classified with 2–3 in the scale named after Höhn and Yahr. The measurement was done in the so called ‘off-state’. The last medical application was on the day before the test. All patients ($n = 21$) in the study were right-handed; they were informed about the aim and goals of the study. There were no significant differences between demographical data within the groups concerning age ($P = 0.294$) or weight ($P = 0.392$). The patients had an average duration of the disease lasting 2.9 ± 0.6 years.

To show the effect of the used music on the motor coordination two different tests were used: on the one hand the ‘Vienna Test Systems’ (Company Dr G. Schuhfried) to measure fine motor coordination. This motor performance series (MPS) is a test battery developed by Schoppe [12] based on Fleishman’s factor-analytic examinations of fine motor abilities in arms [4]. On the other hand we used the power-force-working-plate (Company Advanced Mechanical Technology, Inc.; AMTI) to measure motor coordination in legs.

The tested music (drumming) was self-selected by Parkinson patients (PP) out of two CDs: (1) improvisations by Ron Tutt and Jim Keltner, produced 1981 and printed in USA; and (2) the Sheffield drum record, Sheffield Lab 14 SL 43/44, Direct disc recording limit. ed., Santa Barbara, CA.

The rhythms did not follow a regular metrical pattern. So an adaptation like with a metronome to a consistent external acoustical stimulus was excluded. Thus the effects are due to the physiological influence of the music. In both testings there was no music playing during the measurement.

The following four factors of fine motor abilities were included in the statistical analysis: (1) steadiness; (2) line tracking; (3) aiming; and (4) tapping. The patients have been introduced to the work panel (MPS). One test sequence (right hand and left hand) lasted 10 min. After the first sequence the patient’s listened by stereo-earphones 20 min to the selected music. Then the second testing sequence was performed.

The patients had to make tapping movements on the power-force-working-plate with their legs. Each test sequence consisted of three parts: (1) 5 min break; (2) 5 s test with right leg; and (3) 5 s test with left leg.

Seven sequences (1) A1; (2) A2; (3) M1; (4) M2; (5) M3; (6) B1; and (7) B2 were performed: A1 and A2, two measurements before music application; M1, M2 and M3, Music listening was done before each measurement; and B1 and B2, two measurements after music listening

For statistical analysis, the general linear model procedure for repeated measures (SPLIT-PLOT Designs: SPFP.q, SPFP.q.r) was used.

Fig. 1a shows the results of subtest *aiming error time* in both groups for the left and right hand before and after music listening. The dependent variable was *error time* in seconds. Independent from the group there is a significance within-subject main effect testing with the right hand ($F(1, 19) = 7.253$; $P = 0.015$) and no statistical difference

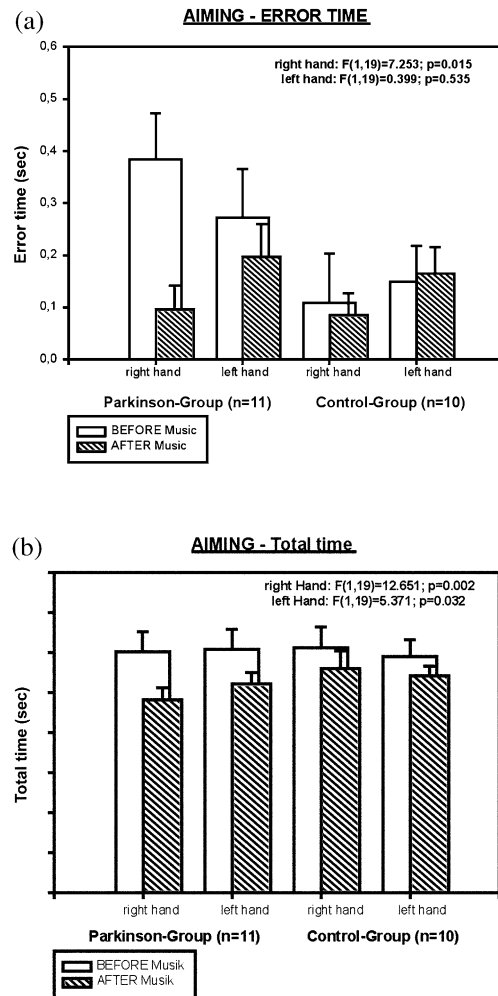


Fig. 1. (a) MPS – aiming error time – mean values \pm SEM. (b) MPS – aiming total time – mean values \pm SEM.

testing with the left hand ($F(1, 19) = 0.399$; $P = 0.535$). A significant interaction was found for the factors ‘group’ and ‘before/after music’, respectively for the right hand ($F(1, 19) = 5.254$; $P = 0.033$).

For the subtest *aiming total time* there is independent from the group a significance within-subject main effect for the right hand ($F(1, 19) = 12.651$; $P = 0.002$) and the left hand ($F(1, 19) = 5.371$; $P = 0.032$) (Fig. 1b). No significant between-subject main effect for the right hand ($F(1, 19) = 0.600$; $P = 0.448$) and for the left hand ($F(1, 19) = 0.000$; $P = 0.992$) was found.

In the subtest *steadiness* the Parkinson group showed a decrease of error time which was not statistically significant for both hands.

The results for the subtest *line tracking error time* decreases in all groups. Independent from the group there is no significant within-subject main effect with the left hand ($F(1, 19) = 2.903$; $P = 0.105$) but a significant effect with the right hand ($F(1, 19) = 14.479$; $P = 0.001$); (mean values: Parkinson group: before: $\bar{x} = 5.67 \pm 0.78$; after:

$\bar{x} = 3.74 \pm 0.8$; Contr. gr.: before: $\bar{x} = 6.03 \pm 1.28$; after: $\bar{x} = 4.74 \pm 0.84$).

For the subtest *line tracking total time* there is independent from the group a main significance within-subject main effect for the right hand ($F(1, 19) = 7.567$; $P = 0.013$) and for the left hand as well ($F(1, 19) = 5.093$; $P = 0.036$) (Fig. 2). The mean of *line tracking total time* decreased 5.42 s (right hand) and 6.08 s (left hand). A significant between-subject main effect with the left hand ($F(1, 19) = 4.813$; $P = 0.041$) was found. No significant interaction resulted for the factors ‘group’ and ‘before/after music’, respectively for the right hand ($F(1, 19) = 0.600$; $P = 0.448$) and for the left hand ($F(1, 19) = 0.000$; $P = 0.992$).

In subtest *tapping*, the number of hits increased in Parkinson group up to 6.81 (right hand) and 2.37 (left hand). The control group showed a decrease of 1.7 (right hand) and 2.2 (left hand). Independent from the group there is no significance within-subject main effect for the right hand ($F(1, 19) = 1.057$; $P = 0.317$) and for the left hand ($F(1, 19) = 0.001$; $P = 0.971$).

For the analysis of the AMTI-data parameters *contact time*, *time of release*, *total step*, *impact maximum*, *frequency* have been recorded. Additionally, we used the variability coefficient (vc). It is used to compare the variances from the different measurements. In this study it is a measure for motor coordination and is expressed as a percentage-value. If vc is decreased after the music application we conclude that motor coordination is better. The tests were done alternating with both feet and the mentioned parameters were recorded. In contrast to the MPS-measurement, the tapping movement showed no difference between the right and the left leg.

Fig. 3 shows the different contact sequences. A contact sequence is referred to as the time when the patient had contact with the power-force-work-plate. As expected, the control group performed the tapping movement very consistently. In contrast the *contact times* decreased about 34 ms in the Parkinson group (A1–M2). Independent from the group and independent whether right or left leg was used, we found a

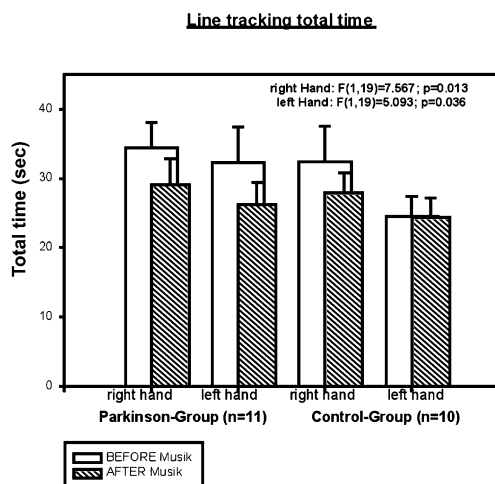


Fig. 2. MPS – line tracking total time – mean values \pm SEM.

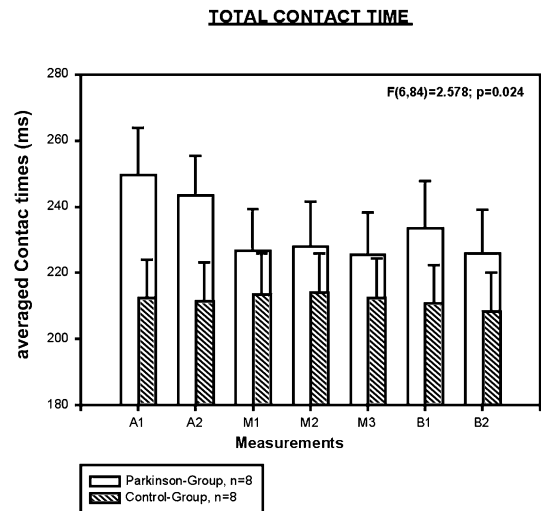


Fig. 3. AMTI – contact total time – mean values \pm SEM.

significance within-subject main effect ($F(6, 84) = 2.578$; $P = 0.024$) for the subtest *contact total time* (Fig. 3).

There is also a significant between-subject main effect ($F(6, 84) = 2.536$; $P = 0.026$). After the application of the music the Parkinson group showed a clear decrease of the variability coefficient (M1–M2–M3). The ANOVA showed a significant difference ($F(6, 84) = 6.241$; $P < 0.000$) for the *variability coefficient of parameter contact total time*. A significant interaction was found for the factors ‘group’ and ‘before/after music’, respectively ($F(6, 84) = 6.546$; $P < 0.000$). Additionally, there is a significant between-subject main effect ($F(1, 14) = 15.012$; $P = 0.002$). The parameter *time of release* (no contact with the power-force-work-plate) showed no statistical difference in none of the groups.

Fig. 4 shows the vc of the parameter *total step*. This parameter is composed of the *contact time* and the *time of release*. After the influence of the music the vc of the Parkinson group decreased significantly (M1–M2–M3). The ANOVA showed a significant difference ($F(6, 84) = 6.296$; $P < 0.000$). A significant interaction was found for the factors ‘group’ and ‘before/after music’, respectively ($F(6, 84) = 4.910$; $P < 0.000$). Additionally, there is a significance between-subject main effect ($F(1, 14) = 14.016$; $P = 0.002$).

The analysis of variance for the parameter *impact maximum* showed no significant difference ($F(6, 84) = 1.442$; $P = 0.208$). In contrast the vc for the parameter *impact maximum* showed a significant difference ($F(6, 84) = 2.340$; $P = 0.039$). A significant interaction was found for the factors ‘group’ and ‘before/after music’, respectively ($F(6, 84) = 0.995$; $P = 0.434$). Additionally, there is a significance between-subject main effect ($F(1, 14) = 7.895$; $P = 0.014$) (Fig. 5).

The calculated analysis of variance for the parameter *frequency* showed no significant difference ($F(6, 84) = 1.611$; $P = 0.154$). A significant interaction

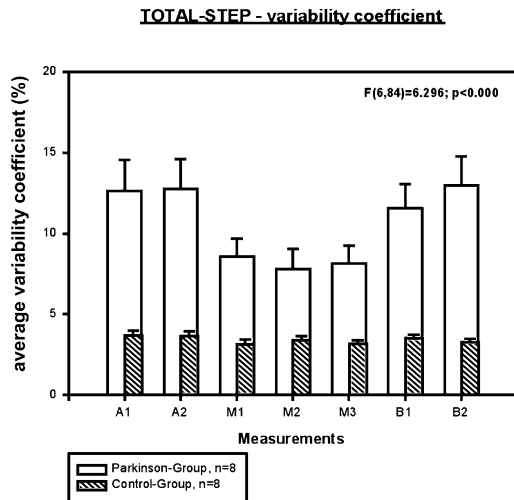


Fig. 4. AMTI – total step – variability coefficient – mean values \pm SEM.

was found for the factors ‘group’ and ‘before/after music’, respectively ($F(6, 84) = 1.165$; $P = 0.333$). Additionally, there is a significance between-subject main effect ($F(1, 14) = 0.062$; $P = 0.807$).

The aim of this investigation was to prove the short-time effect of stimulating music on motor coordination of PP. A lot of previous results show the influence of music on humans as well as animals. Most of these studies deal with the effect of *active* music therapy on humans [5,6,8,9,15,16]. In a particular study, significant differences in motor activity of PP through acoustical stimulation were carried out [16]. They explain the increase in gait velocity and longer stride length as a merging between the external acoustical metronome rhythm and the gait rhythm. In the present study the effects of *receptive* music application was the central topic. It is not clear how the motor system is physiologically connected to acoustical stimulation. Presumed is, that an ontological connection exists between the motor and the auditory system. Special external acoustical signals alarm the brain and body and cause an activation of

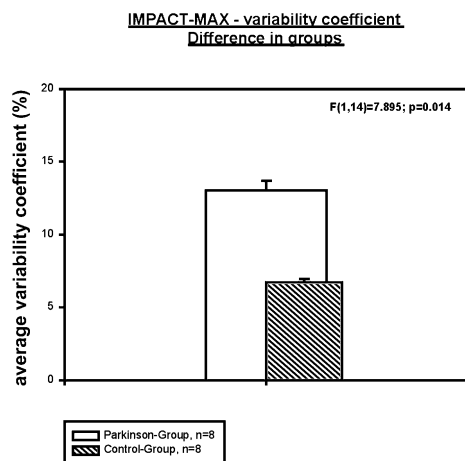


Fig. 5. AMTI – impact maximum – variability coefficient – mean values \pm SEM.

motor systems. In former times this reaction was essential to survive. In a holistic treatment the Parkinson symptoms decrease when patients listened to joyful and relaxing music [14]. PD additionally decreases the ability to generate movement automatically (from the primary motor cortex in the frontal lobe via neural connections to extremities). It is assumed that music helps patients to remember in long term memory stored movement programs. In accordance there is evidence that music evokes dancing movements in the patients [16]. In our study, six subjects felt an easiness and sleaziness after listening to the music. This feeling was surprising because they expected a decrease of their performance due to the time of day and the unmedicated state. Accordingly, we showed that most of the subjects were able to find easy access to fast rhythmic movements in the so called ‘off-state’. Statistical analysis gives evidence that PP do not deteriorate in any of the recorded parameters.

In the Parkinson group the measurement with the ‘Vienna Test System’ showed an improvement in two (aiming, line tracking) of four subtests after listening to the music (Figs. 1a,b and 2). When analysing error time as well as the total time in the subtest Aiming significant statistical effects were found for both hands with higher differences in the right hand (Fig. 1b).

We do have evidence that receptive listening to music improves fine motor coordination in PP. Even the hand-arm-coordination improved. There was no significant variation in the other two subtests (steadiness, tapping) in both groups. This result is in accordance to the measurements on the power-force-working-plate. Additionally, there was also no improvement in the frequency of the tapping movement of the feet. On the basis of these results we conclude that stimulating music effects more the precision of a movement than the speediness.

The tapping frequencies in arms and legs showed the expected differences. The increased speediness of the upper extremities is based on a higher contingent of fast-twitch muscle fibres and further that the releasing frequency of motoneurons decreases ascending from head to feet.

The measurements on the AMTI-working plate showed a significant improvement in two of five measured parameters: contact time, variability coefficient for total step and impact maximum changed significantly (Figs. 3–5).

Our data partially support the hypothesis that receptive listening to music improves motor coordination in PP. We can also assume that this result reflects a short-time effect because the values of the variability coefficient increase 5–10 min after listening to the music.

We still do not know whether the effect is due to a direct processing of the external signal or to a modified production of special neurotransmitters.

The parameter impact maximum shows a significant difference but can not be assigned clearly to one group (Fig. 5). There is a decreasing tendency in the data of the Parkinson group. The parameter time of release and frequency showed no significant differences in both groups.

We also implemented the state trait anxiety inventory-questionnaire [13] before and after listening to the music, but no statistical changes were found in both groups. Therefore we conclude that the specific music applied in this study does not change the assessment of mood.

Within this study we showed that a specific stimulating music improved the precision of arm and finger movements.

Basically we found strong evidence that the used stimulating music effects motor coordination of Parkinson patients. It is necessary to find out which specific elements or patterns of music are responsible for this physiological effect. It also has to be investigated how long a patient has to listen to the music and how long lasting is the physiological response. We are definitely aware to the fact that additional studies are required to understand the physiological effects of music.

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