Sensory-motor synchronization with musical and non-musical stimuli in patients with Parkinson's disease

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INTRODUCTION

The ability to synchronize with auditory stimuli is ubiquitous. This can be observed when people listening to music spontaneously or deliberately move in synchrony with its beat (e.g. by foot tapping). Malfunctioning of the basal ganglia–cortical circuits, as observed in Parkinsons' disease (PD), can affect timing and sensory-motor synchronization (SMS) (e.g. Diedrichsen, et al., 2003; Harrington et al., 1998; but see Ivry & Keele, 1989). Still, the role of the basal ganglia in SMS is unclear.

GOALS

(1) **Examine the contribution of the basal ganglia to SMS with auditory stimuli from different domains (i.e. musical vs. non-musical stimuli)**

(2) **Assess whether impaired SMS results from a time perception deficit**

METHOD

PARTICIPANTS

	PD patients (n = 29)	Controls (n = 27)
Age (years)	67,5 (SE = 12)	68,0 (SE = 13)
Education (1-4)	1,8 (0,9)	2,0 (1)
Sex	16 H / 13 F	12 H / 15 F
Duration of disease	8,8 years (4,5)	
MMSE (>24)	28,6 (1,4)	
BDI (1-21)	10,7 (7,1)	

	PD patients (ON-state) (n = 26)
UPDRS (Fahn et al., 1987)	1,3 (13,3)
Hoehn & Yahr (1967)	Stage 0 = 2 patients Stage 1 = 1 p. Stage 2 = 10 Stage 2,5 = 7 Stage 3 = 3 Stage 4 = 3
Schwab & England (1997)	78 (11,5)

TASKS

Tapping tasks

1) **Spontaneous** (unpaced) **tapping**

2) **Paced tapping**, along with

Metronome	Isochronous sequence of 96 non-musical sounds
Music	An excerpt of a familiar piano musical piece (Radetzky March) (96 musical beats)
AM Noise	Amplitude-modulated noise derived from music

Musical and non-musical stimuli were computer-generated.

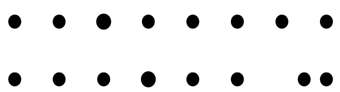
For each paced tapping condition, we used 3 Inter-beat-intervals (IBIs): **450, 600, and 750 ms**.

The order of paced tapping conditions was counter-balanced across-subjects. IBIs were counterbalanced within-subjects.

Time perception tasks

(anysochrony detection tasks)

1. **Metronome**



Instructions: Did you detect a change in the regularity of the sequence? (Yes/No)

2. **Music**

Two fragments (8 musical beats) of the same excerpt used in paced tapping tasks (music condition) were used. Beat isochrony was manipulated as in the metronome task.

Instructions: Did the pianist make a mistake during the performance (i.e. a note was played earlier or later than expected)? (Yes/No)

In both tasks we manipulated isochrony in Change trials (50% of the trials) by presenting the 7th sound or musical beat earlier or later by one of three temporal increments: 8%, 12%, or 16% of the IOI.

The tasks were performed using the same IOIs adopted in the paced tapping tasks (i.e. 450, 600, and 750 ms).

The order of the tasks was counterbalanced across-subjects and IOIs were counterbalanced within-subjects.

PD patients were tested in ON-state.

QUESTION 1

Were PD patients as accurate as Controls in spontaneous tapping?

	PD patients	Controls
N. of taps	94.0	73.9
ITI (inter-tap intervals, in ms)	568.3	613.2
CV of the ITI	**0.18**	**0.06**

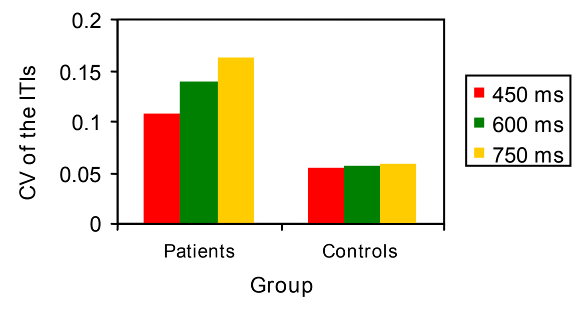
PD patients were more variable than Controls ($t(54) = 4.11$, $p < .001$)

CV of the ITI was correlated with MMSE ($r = -0.47$, $p < .05$) and Duration of disease ($r = 0.51$, $p < .01$)

QUESTION 2

Were PD patients as accurate as Controls when they synchronized with an auditory stimulus?

CV of the ITI (inter-tap-intervals)



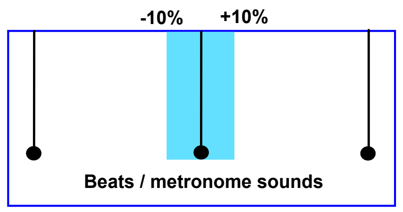
PD patients were more variable than Controls ($F(1,53) = 20.05$, $p < .001$) and more sensitive to IOIs ($F(2,106) = 5.35$, $p < .01$)

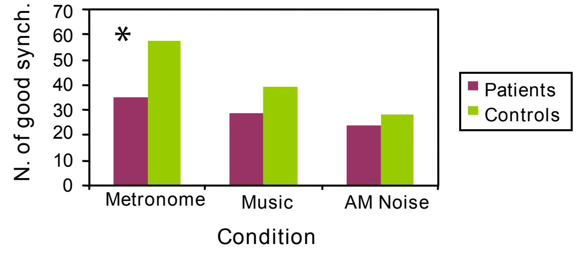
CV of the ITIs in the Music condition was correlated with MMSE ($r = -0.38$, $p < .05$)

Number of Good synchronizations

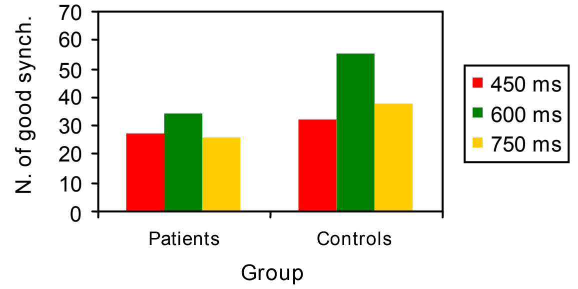
Good synchronization

When the tap occurred in the vicinity (± 10% of the IOIs) of musical beats or metronome sounds





Patients exhibited a smaller n. of good synchronizations than Controls, in particular in the Metronome condition ($F(1,53) = 12.39$, $p < .01$)

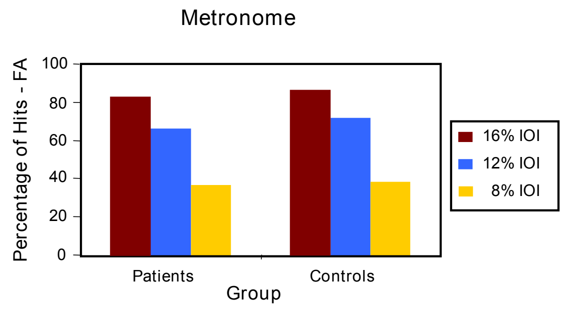


Larger number of good synchronization with 600-ms IOI

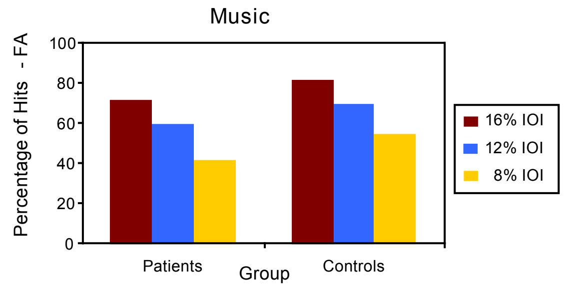
This effect was more evident for Controls than for Patients ($F(2,106) = 3.93$, $p < .05$)

QUESTION 3

Did PD patients perceive anysochrony similarly to Controls?



Patients did not differ from controls in the Metronome condition



Patients were slightly worse than Controls at detecting asynchronies in the Music condition ($F(1,54) = 6.80$, $p < .05$)

This mild perceptual deficit observed in PD patients was not related with their synchronization performance in the Music condition (correlation between N. of good synchronizations and percentage of Hits-FA: $r = 0.10$, n.s.)

QUESTION 4

Did PD patients' individual performance reveal dissociations between conditions?

Dissociation between conditions
(n. of good synchronizations, IOI = 600 ms)

Metronome	Music	AM Noise	n. of patients
O	O	O	18
X	O	O	3
O	X	X	3
X	O	X	2
O	O	X	1
O	X	O	1
X	X	X	1

Double dissociation Metronome vs. Music/AM Noise

Double dissociation Music vs. AM Noise

X = impaired, O = normal

Conclusions

PD patients are impaired when they have to synchronize their movement with auditory stimuli. Such impairment is more important when synchronizing with simple isochronous sequences than with other auditory stimuli (e.g. music).

Individual performances revealed that this synchronization deficit can selectively concern one category of auditory stimuli (e.g. music or non-musical stimuli).

PD patients synchronization deficit does not seem to results from deficient time perception. Rather, mechanisms linked to motor planning and coordination are likely to be impaired.

References

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