Effect of pallidotomy on sensorimotor synchronization in Parkinson's disease

Ilona Laskowska[a,b], Simone Dalla Bella[a], Paulina Rolinska[a], Aleksander Litwinowicz[c], Edward J. Gorzelanczyk[b], & Marek Harat[c]
[a] Dept. of Cognitive Psychology, University of Finance and Management in Warsaw, Poland; [b]Dept. of Neuropsychology and Behavioural Genetics, Kazimierz Wielki University, Bydgoszcz, Poland;
[c] Dept. of Neurosurgery, 10th Military Hospital in Bydgoszcz, Poland

INTRODUCTION

When we listen to rhythmic auditory stimuli (e.g., music) we often spontaneously or deliberately move in sync with their beat (e.g., by foot tapping). **Sensorimotor synchronization (SMS)** in tapping tasks has been consistently tied to the activity of the **cerebellum** and of the **basal ganglia**, as indicated by lesion studies (i.e., with patients with cerebellar lesions or suffering from Parkinson's disease) and neuroimaging (Wing, 2002). Accordingly, these brain structures have been proposed to be the cornerstone of an internal system for time perception and production (Harrington, 1998; Ivry, 1997). Still, the role of the basal ganglia in SMS is little understood.

GOALS

(1) **Examine the contribution of the basal ganglia to SMS to auditory stimuli from different domains (i.e., musical vs. non-musical stimuli) by studying the effect of the ablation of the postero-ventral portion of the Gpi (i.e., pallidotomy) on SMS**

(2) **Assess whether SMS and the performance in anisochrony detection tasks dissociate following surgery**

METHOD

PARTICIPANTS

Experimental group
10 nondemented medicated patients with intractable PD submitted to pallidotomy (ablation of the postero-ventral portion of the Gpi)

Control patients
10 nondemented medicated patients with PD

Healthy controls
10 participants matched to the Experimental group

	Exp. Group	Ctrl pat.	Healthy ctrl
Age (years)	61.8 (SE = 2)	63.6 (SE = 2)	62.1 (SE = 3)
Educ. (1-4)	2.1 (0.4)	1.8 (0.3)	2.1 (0.4)
Sex	6 H / 4 F	6 H / 4 F	6 H / 4 F
Dur.disease (years)	12.3 (2.2)	10.0 (1.4)	-
MMSE (>24)	27.5 (0.4)	28.7 (0.5)	29.0 (0.4)

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 and the IBIs were counterbalanced across-subjects.

Anisochrony detection tasks

1. **Metronome**

● ● ● ● ● ● ● ● **No change**

● ● ● ● ● ● ●● **Change**

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 IBI.

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

Patients in the Experimental group were tested 2 days before (*pre-surgery*), three months, and 6 month following pallidotomy. Control patients and healthy controls were tested only once.

All PD patients were tested in ON-state.

The order of the IBIs was counterbalanced across-subjects.

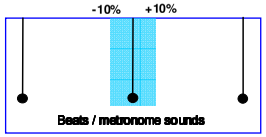
QUESTION 1

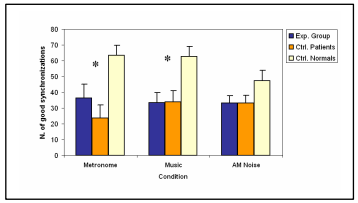
Was the Experimental group impaired in SMS before pallidotomy as compared to Controls?

Number of *Good synchronizations*

Good synchronization

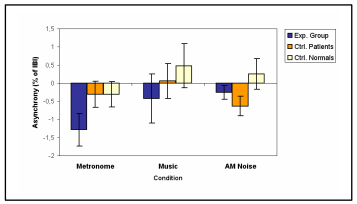
When the tap occurred in the vicinity (± 10% of the IOIs) of musical beats or metronome sounds





The Experimental group produced a N. of good synchronizations comparable to the control patients, but lower than healthy controls. This difference reached significance in the Metronome and Music conditions ($p < .01$).

Asynchrony (% of the IBI)



Asynchrony between the taps and the pacing stimuli seemed larger for the Experimental group than for controls (at least in the Metronome condition). However, this trend did not reach significance.

QUESTION 2

Did pallidotomy affect accuracy in SMS with auditory stimuli?

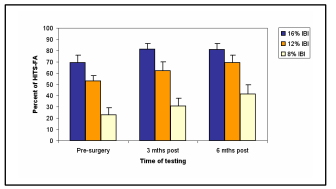
	Pre-surgery		Post-surgery (3 mths)		Post-surgery (6 mths)	
	N. good sync	Async (% IBI)	N. good sync	Async (% IBI)	N. good sync	Async (% IBI)
CONDITION	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)
Metronome	36.4 (8.8)	-1.3 (.5)	31.9 (10.6)	-1.2 (.5)	30.0 (8.6)	-1.6 (.6)
Music	33.4 (8.1)	-0.5 (.6)	33.6 (9.4)	-0.4 (.7)	25.0 (7.8)	-0.8 (.6)
AM Noise	33.2 (6.3)	-0.1 (.6)	26.5 (7.1)	-0.6 (.4)	23.2 (7.8)	-0.1 (.4)

Pallidotomy did not significantly affect temporal accuracy in SMS, as attested by the N. of good synchronizations and Asynchrony, measured 3 months and 6 months after surgery. Only very few patients in the Experimental group exhibited improved synchronization accuracy 3 and 6 months after surgery. Most patients either maintained the initial performance or exhibited worse accuracy.

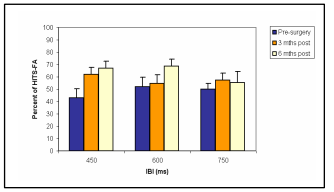
QUESTION 3

Did pallidotomy affect the detection of anisochronies?

Metronome

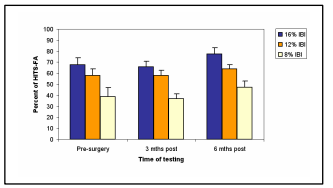


PD patients were able to detect anisochronies in isochronous sequences above chance (for 16% and 12% of the IBI), both before and after surgery ($F(2, 18) = 46.4$, $p < .001$).

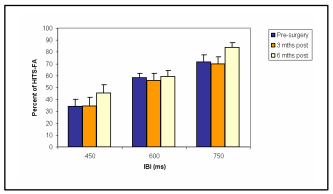


Their ability to detect anisochronies improved after surgery, in particular with 450 and 600 ms IBI ($F(4,36) = 2.9$, $p < .05$)

Music



PD patients were able to detect anisochronies in musical sequences above chance (for 16% and 12% of the IBI), both before and after surgery ($F(2, 18) = 39.1$, $p < .001$).



However, **in a musical context, PD patients' ability to detect anisochronies did not significantly improve after surgery**.

Conclusions

Pallidotomy did not lead to improved accuracy in SMS tasks with different auditory stimuli in PD patients. In most of the cases PD patients exhibited similarly impaired SMS both before and after surgery.

In contrast, pallidotomy had a positive effect on time perception: the detection of anisochronies improved 3 and 6 months after surgery. This effect was visible only with non-musical material.

These findings suggest that SMS and the detection of anisochronies may be supported by partly independent neuronal substrates.

References

Wing, A. M. (2002). Voluntary timing and brain function: an information processing approach. *Brain and Cognition, 48*(1), 7-30.

Harrington, D. L., Haaland, K. Y., & Hermanowicz, N. (1998). Temporal processing in the basal ganglia. *Neuropsychology, 12*(1), 3-12.

Ivry, R. (1997). Cerebellar timing systems. *International Review of Neurobiology, 41*, 555-573.