Dopaminergic Influences on Temporal Variability During Movements in Parkinson’s Disease: A Sensory Connection?

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PURPOSE
To determine how dopaminergic treatment influences on temporal control during finger movements in PD

HYPOTHESIS
Dopaminergic influences on temporal control will be dependent on availability of cutaneous feedback and task complexity.

KEY FINDINGS
Use of cutaneous feedback to improve temporal control is dopamine dependent, especially in bi–axial movements.

Background
• The basal ganglia are thought to contribute to temporal control, possibly through the integration of proprioceptive feedback. These functions may be disrupted in Parkinson’s disease (PD) due to the degeneration of dopaminergic neurons within the basal ganglia1,2
• In contrast to simple (uni-axial, finger tapping) movements, complex (bi-axial, circle drawing) movements may increase demand, necessitating the need for cutaneous to improve temporal accuracy.
• Parkinsonian medications affecting the dopaminergic system are the most common treatments for PD, but the influence on temporal control has been debatable.3

Methods
• 20 PD patients (mean age 68 ± 8.6, mean UPDRS score OFF medication 30.5 ± 8.3 and ON medication 20.2 ± 7.6).
• 2 finger tapping and 2 circle drawing tasks with and without the cutaneous cue of touching a table.
  • Uni-axial (sagittal plane) i. table (FTTB) ii. air (FTair)
  • Bi-axial (frontal plane) iii. table (CDTB) iv. air (CDair)
• External auditory cue provided by a metronome at varying target cycle durations
• Participants were tested OFF and ON dopaminergic medication with left and right hand pooled together
• Trial duration: 15 seconds
• Optotrak® system collected kinematic and temporal data
• RM ANOVA: Temporal variability of the inter-tapping time (completion time per tap), within each task.

Results
• Significant interaction between medication and task (F(1,19)=9.69, p<0.01) on table.
  • CDTB: PD OFF (m=0.082 ± 0.010) was less variable than PD ON (m=0.103 ± 0.013)
  • CDair: PD OFF showed greater variability (m=0.105 ± 0.014) compared to PD ON (m=0.085 ± 0.009) (Figure 2)
• When the tasks were performed in the air, CDair was more variable then FTair ON and OFF medication (Figure 3).

Discussion
• Simple uni-axial movements were performed with greater temporal control in the OFF dopaminergic state, with cutaneous feedback (Compared to ON).
• In contrast complex bi-axial movements were performed with greater temporal control in the ON dopaminergic state, with cutaneous feedback (Compared to OFF) (Figure 4 & 5).
• Without cutaneous feedback available complex bi-axial movements are always performed with increases temporal variability (Compared to uni-axial).
• Cutaneous feedback is a vital source of information during complex movements. Individuals with PD may rely on cutaneous feedback to drive a compromised proprioceptive system.

Conclusion
• Our results suggest that in simple movements temporal control can be regulated cortically without the involvement of the basal ganglia, where as more complex movements may benefit from additional cutaneous feedback that may be facilitated by the basal ganglia in the ON state.

Key References