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Research report

Drug treatment and familiar music aids an attention shift from vision to somatosensation in Parkinson's disease on the reach-to-eat task

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ABSTRACT

Sensory control of the natural skilled movement of reaching for a food target to eat (reach-to-eat) is closely coupled to the successive phases of the movement. Control subjects visually fixate the target from hand movement onset to the point that the digits contact the food, at which point they look away. This relationship between sensory attention and limb movement suggests that whereas limb advance is under visual control, grasping, limb withdrawal, and releasing the food to the mouth is guided by somatosensation. The pattern of sensory control is altered in Parkinson's disease (PD). PD subjects may visually fixate the target for longer durations prior to movement initiation, during the grasp, and during the initial portion of hand withdrawal suggesting that vision compensates for a somatosensory impairment. Because both medication and listening to favorite musical pieces have been reported to normalize some movements in subjects with PD, the present study compared the effect of medication and listening to preferred musical pieces on sensory attention shifts from vision to somatosensation during the reach-to-eat movement. Biometric measures of eye movement and the movement of the reaching limb were collected from PD subjects and aged-matched control subjects in four conditions in their own homes: off medication, off medication with music, on medication, and on medication with music. Unmedicated PD subjects were slower to visually disengage the target after grasping it. Their disengage latency was shortened by both music and medication. Medication and music did not improve other aspects of reaching, including reaching duration and the ratings of the movement elements of limb advance, grasping, and limb withdrawal. The results are discussed in relation to the idea that one way in which medication and music may aid movement in PD by normalizing somatosensory control of forelimb movement thus reducing compensatory visual monitoring.

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1. Introduction

Skilled reaching, or reach-to-eat, is a natural movement in which a hand is used to grasp a food item and place it in the mouth for eating. Because the movement is present in rodents, nonhuman primates, and humans, it routinely serves as a laboratory model to investigate a variety of neurological conditions, including stroke [20,21], spinal cord injury [22,59], and degenerative disorders such as Huntington's disease and Parkinson's disease (PD) [14,16,27,33,58]. Sensory monitoring of the reach-to-eat movement in human subjects is distinctive in that it is closely coupled to the phases of the movement. Control subjects visually fixate the target with a quick eye saccade just before the limb initiates the advance movement to the food and then disengages the target with an eye blink and an alteration in gaze just at the point that the digits contact the food. The coupling of "visual attention" to limb advance suggests that whereas limb advance is under visual control, grasping, limb withdrawal, and releasing the food into the mouth is guided by somatosensory feedback [13]. The relation of sensory attention to the phases of the reach-to-eat movement makes the task useful for investigating the shifts in sensory control (i.e., visual and somatosensory) of movement in neurological disease such as PD.

PD is caused by the progressive degeneration of dopamine producing neurons in the substantia nigra pars compacta [12] and is characterized by motor, sensory, and attention impairment [32,46]. In addition, Lewy body inclusions have been noted in the temporal cortex of confirmed stage III PD patients as assessed by Braak classification [7], suggesting widespread neural changes in the disease. Forelimb movement impairments have been described in both laboratory-based tasks [17,43] and real-world tasks [9,15,57]. They are often accompanied by sensory impairments [3,19,28,29] and if sensory cueing is provided to PD subjects, motor performance can improve [8,11,30,56]. To illustrate, illumination of the finger improves performance on memory guided pointing [1] in much the same way that auditory (i.e., verbal instructions) or visual (i.e., lines

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on floor) cueing can improve cadence, stride length and velocity of gait for PD subjects [2,30]. In addition, reducing visual monitoring of the hand results in greater hand shaping abnormalities [50]. Both dopaminergic medication and music can ameliorate PD symptoms [15,37,39,46,47,53,55,56] but the extent to which the treatments act on movement vs. sensory control is unclear.

The findings that medication and music can have a beneficial effect on movement and its sensory control in PD is interesting and raises the question of whether these treatments might affect sensory monitoring and sensory shifts in the reach-to-eat task. Previous work suggests that, whereas control subjects visually engage a food item in the reach-to-eat task just as they initiate the reach movement and visually disengage the target immediately upon grasping the target [13], PD subjects fixate the target for a longer duration both prior to reach initiation and following grasping [33,47]. The purpose of the present study was to examine whether an alteration in sensory shifting from vision to somatosensation occurs in unmedicated PD patients and to determine the effects of medication and familiar music on sensory attention shifting. Age-matched controls (OAC), and adults with PD performed the reach-to-eat task. Eye movements were monitored with an eye-tracking system and hand movements were monitored by video recording and analyzed with kinematic tracking. PD subjects were tested under four conditions in their own homes: off medication, off medication with familiar music, on medication, and on medication with familiar music, and were compared to age-matched controls. Synchronized data from the ulnar styloid process (reach wrist) and the eye-tracking system were compiled to determine the extent of visual guidance to the reach-to-eat movement and the effects of familiar music and/or drug treatment on sensory monitoring of the movement. In addition, movement components of the reach-to-eat movement were examined using a previously standardized rating scale [34,60].

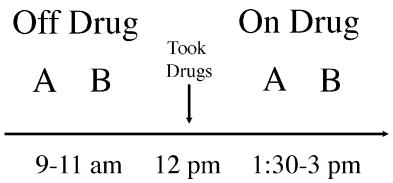

Fig. 1. Procedural timeline for the Parkinson's disease subjects. Testing in the off condition began at 9:00 A.M., medication was administered at 12:00 P.M., and testing in the off condition began at 1:30 P.M. A – testing off music; B – testing on music.

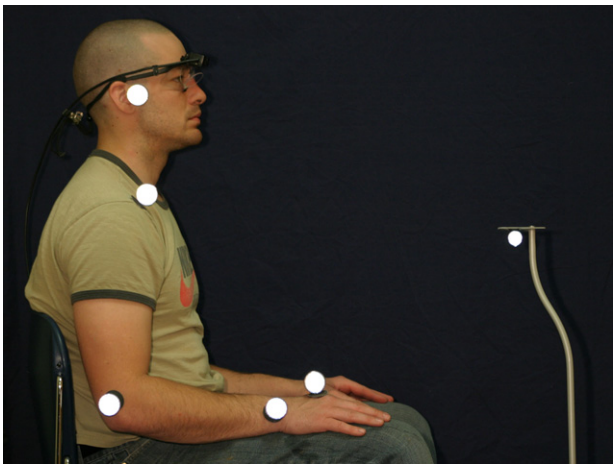

Fig. 2. A subject sits before a pedestal on which a food item is placed. Food is placed on the pedestal and the subject begins the first reach with hand open on the lap. The white dots represent light reflective markers on the subject (left) and the food target (right). The headset is for eye-tracking.

2. Materials and methods

2.1. Subjects

PD subjects were recruited from the Parkinson's Society of Southern Alberta (PSSA) city of Lethbridge, Alberta chapter (6 males and 2 females; ages 70.3 ± 6.8 years; Hoehn and Yahr "OFF" mean = 2.0). Individuals were diagnosed with Parkinson's disease by a neurologist with expertise in movement disorders at a local Parkinson's disease clinic (in Raymond, Alberta). PD subjects were all receiving dopaminergic medications as PD treatment, and were tested in both off (>12 h removed from last oral drug dose (as per previously described methodology [26,38,45]; UPDRS motor subset off 32.9 ± 12.9)) and on (testing commenced 1.5 h following oral administration of PD medication; UPDRS motor subset on 24.1 ± 10.2) medications. Testing in the "ON" condition occurred 1.5 h following oral administration of PD medications for two reasons. The plasma half-life of levodopa occurs 1–3 h following oral dosing [23] and PD subjects self-reported that they felt their medication was working 1.5–2 h following administration (see Fig. 1 for the methodological timeline). Testing in both conditions occurred on the same day at the subjects' place of residence, with testing in the off condition occurring in the morning and testing in the on condition occurring in the afternoon. The design of the experiment allowed the study to be conducted on a single day for each subject, thus reducing testing stress associated with multiple test sessions. Clinical assessment on the basis of the UPDRS III motor subset confirmed the quality of the on condition (paired t for on vs. off medication: $p = 0.001$). For PD subject characteristics, see Table 1.

Age-matched old adult control (OAC) subjects were recruited from the city of Lethbridge through newspaper advertisement (3 males and 5 females; ages 69 ± 5.78 years). There was no significant age difference between the two groups ($p = 0.70$). All control subjects were self-reported to be in good health with no history of neurological disorder, and all subjects had normal or corrected to normal (contact lens) vision. The University of Lethbridge Human Subject Research Committee approved the study. Informed consent was obtained from subjects prior to initiation of the testing session. The study was conducted in accordance with the Declaration of Helsinki.

2.2. Reaching task

Subjects performed a seated reach-to-eat task in which they reached toward a pedestal for a small food item that was grasped and withdrawn to the mouth for eating [13,34,60]. Subjects were seated in a comfortable upright position, with their feet flat on the floor (Fig. 2). A self-standing height adjustable pedestal was placed directly in front of the subject at a horizontal reach amplitude normalized to the subjects' arm length (100% of length from shoulder to tip of index finger with elbow at 180° flexion) and a vertical amplitude normalized to the subjects' trunk height (100% of height from floor to outstretched arm while seated and with shoulder at 90° flexion).

Table 1
Parkinson's diseased subjects characteristics.

ID	Age	Sex	Hoehn and Yahr	UPDRS III ON	UPDRS III OFF	Medications
JD	72	M	1.5	18	22	Sinemet; Mirapex
ES	77	M	3	31	36	Sinemet
RM	75	M	1.5	20	29	Sinemet
SC	76	F	2	23	38	Carbidopa
DV	67	M	1.5	16	25	Sinemet
LV	68	F	3	44	56	Sinemet
DN	56	M	1	12	15	Sinemet
LVau	71	M	2.5	29	42	Sinemet
Average	70.25	2F:6M	2	24.125	32.875	Sinemet

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