Motor Sequences And The Basal Ganglia: Kinematics Not Habits
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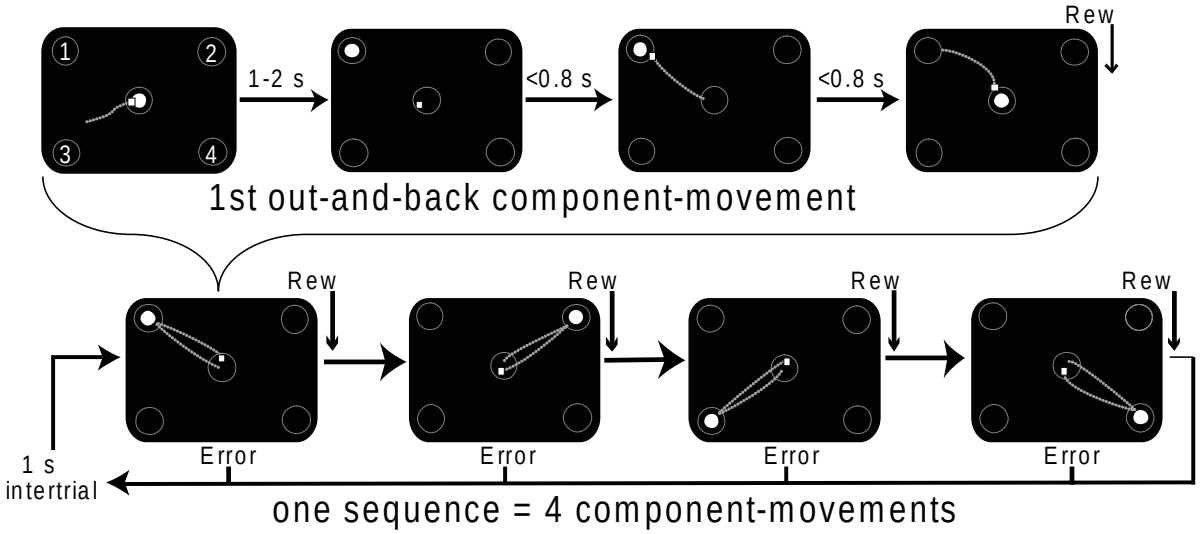
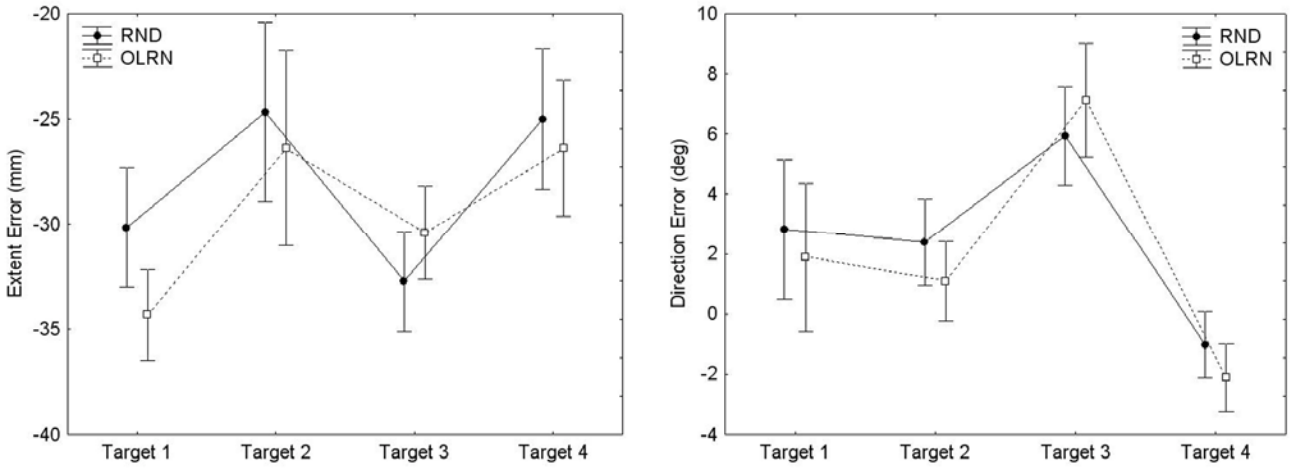
SUPPLEMENTAL DATA

SUPPLEMENTAL FIGURE 1



Schematic representation of the behavioral task and apparatus. Each successful out-and-back movement (top line) was followed by a food reward (*Rew*). Each sequence was composed of four-such out-and-back movements (second line). Numbers 1 to 4 in the first panel of *A* define target numbers. *Open circles*: target locations. *White filled circle*: instruction cue. *Small white square*: joystick-controlled cursor. Movements of the cursor are denoted by a dotted trail.

SUPPLEMENTAL FIGURE 2



Extent and Direction errors for the RND and OLRN conditions, as a function of the target location. Extent errors are defined as the difference between the actual movement extent (norm of the vector joining the starting point to the movement end-point) and the required movement extent (norm of the vector joining the starting point to the target). Direction errors are defined, in the same way, as the angular difference between the actual movement direction (eccentricity of the movement end-point) and the required movement direction (eccentricity of the target). Neither the target location nor the experimental condition affected extent error (3-way between (animals) by within (condition, target location); simple effects and interaction, all ps > .08). Direction errors were affected by the target location ($F_{(3,\ 51)} = 3.1$, $p < .04$) but not by the experimental condition ($F_{(1,\ 17)} = 3.8$, $p > .06$). The condition by target interaction was not significant for this parameter ($F_{(3,\ 51)} = 1.8$, $p > .15$)

SUPPLEMENTAL INFORMATION

Supplemental analyses were performed to determine if animals were able to switch between RND and OLRN blocks without explicit cues, after a single transition trial, and if sGPi inactivation affected that ability. Successful ability to switch task performance quickly between RND and OLRN blocks would be manifested by a close similarity between the first post-transition trial of a block (i.e. the second trial of a block) and all following trials of the block. To investigate this issue, we computed for each block the kinematic characteristics of: (i) The first post-transition trial (P-trial), (ii) The 3 trials following the P-trial (F-trials; average of trials 3 to 5); (iii) The last 3 trials of a block (L-Trials; average of the last 3 trials). P-trials, F-trials and L-trials were then averaged across blocks for each condition and session. ANOVA were used to test for effects of the position of trials within blocks both before injections [3-way between (animals) × within (condition, trial-rank)] and as a function of injections [4-way between (animals) × within (condition, injection, trial-rank)].

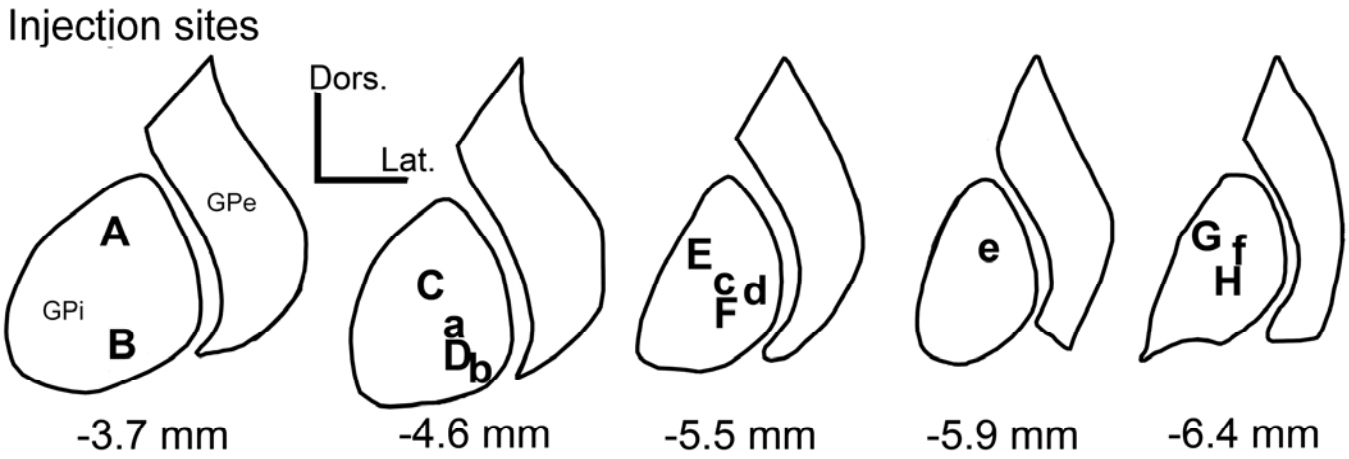
Pre-injection analyses failed to identify significant differences between the first post-transition trial and the following trials. In particular, no simple effect of the trial-rank and no trial-rank -by-condition interactions were found for the main kinematic landmarks of the sequence including: total sequence duration ($Fs_{(2,34)} < 2.7$, $p > .08$), total time spent moving in the sequence ($Fs_{(2,34)} < 2.2$, $p > .10$), rate of aborted trials ($Fs_{(2,34)} < 0.6$, $p > .60$), delay of movement initiation (i.e. reaction time of the first component movement; $Fs_{(2,34)} < 2.7$, $p > .08$), and mean spatial error (root mean square end-point error averaged across the four component movements; $Fs_{(2,34)} < 1.3$, $p > .25$).

Post-injection analyses confirmed the results above regarding the absence of trial-rank effects and also failed to reveal any significant influence of sGPi blockade on the ability to switch

task performance quickly between RND and OLRN blocks. In particular, no injection-by- trial-rank interaction was found for the main kinematic landmarks of task performance: total sequence duration ($Fs_{(2,34)} < 1.0$, $p > .40$), total time spent moving in the sequence ($Fs_{(2,34)} < 1.3$, $p > .30$), rate of aborted sequences ($Fs_{(2,34)} < 1.8$, $p > .15$), delay of sequence initiation ($Fs_{(2,34)} < 2.3$, $p > .10$), mean sequence spatial error ($Fs_{(2,34)} < 1.5$, $p > .25$).

Together, these results confirm that the animals switched task performance easily between RND and OLRN blocks after a single transition trial in the absence of explicit cues indicating that a switch had occurred. This ability is not surprising given the extensive training the animals received (> 50,000 trials; see main text) and the obvious difference between OLRN (same targets presented in a fixed predictable order) and RND trials (randomly selected targets presented in an unpredictable order). Preservation of this fluent switching ability during sGPi inactivation runs contrary to the concept that the BG motor circuit plays a central role in this form of switching behavior (Cools et al., 1984; Cools et al., 2006).

SUPPLEMENTAL FIGURE 3



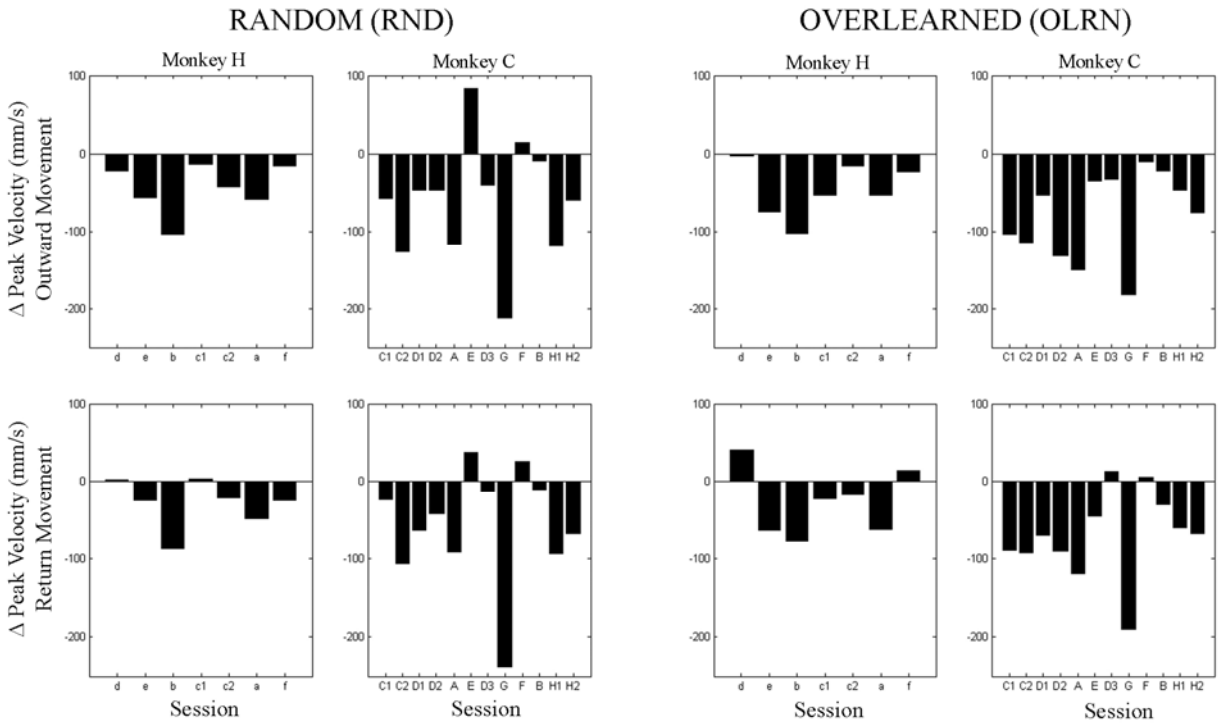
Sites of individual injections reconstructed from histology in monkeys H (*lower-case letters*), and C (*capital letters*). The letters correspond with those in Table S1. Distances indicate the estimated position of the coronal section relative to the anterior commissure. The nuclear boundaries shown were derived as line drawings from a standard atlas (Szabo and Cowan, 1984) subsequently warped to align with nuclear boundaries reconstructed from histologic sections from both animals.

SUPPLEMENTAL TABLE 1

MONKEY	Location (see Figure S2)	Injection	Volume	Distance from anterior commissure	Time of Injection (days)
H	a	muscimol	0.5µg / 0.5µl	-4.6	+29
H	b	muscimol	1.0µg / 1.0µl	-4.6	+8
H	c_1	muscimol	0.5µg / 0.5µl	-5.5	+20
H	c_2	muscimol	0.5µg / 0.5µl	-5.5	+26
H	d	muscimol	2.0µg / 2.0µl	-5.5	1 (ref)
H	e	muscimol	2.5µg / 2.5µl	-5.9	+4
H	f	muscimol	0.5µg / 0.5µl	-6.4	+34
C	A	muscimol	0.5µg / 0.5µl	-3.7	+56
C	B	muscimol	0.5µg / 0.5µl	-3.7	+351
C	C_1	muscimol	0.5µg / 0.5µl	-4.6	1 (ref)
C	C_2	muscimol	0.5µg / 0.5µl	-4.6	+13
C	D_1	muscimol	0.5µg / 0.5µl	-4.6	+16
C	D_2	muscimol	1.0µg / 1.0µl	-4.6	+22
C	D_3	muscimol	2.0µg / 2.0µl	-4.6	+335
C	E	muscimol	0.5µg / 0.5µl	-5.5	+70
C	F	muscimol	0.5µg / 0.5µl	-5.5	+349
C	G	muscimol	0.5µg / 0.5µl	-6.4	+345
C	H_1	muscimol	0.5µg / 0.5µl	-6.4	+541
C	H_2	muscimol	0.5µg / 0.5µl	-4.6	+545

Subscripts denote repeated injections at one location. Ref: reference (first injection day)
The data in the column location refer to supplemental Figure S2.

SUPPLEMENTAL FIGURE 4



sGPi inactivation consistently induced movement slowing across sessions in both monkeys. Each bar represents the difference in peak velocity between the pre- and post-injection phases, for one injection session. Session labels (monkey H: a - f; monkey C: A - J) correspond to those used in Figure S3 and Table S1. Top line: outward movement. Bottom line: return movements.

References

Cools AR, Jaspers R, Schwarz M, Sontag KH, Vrijmoed-deVries M, van den Bercken J (1984) Basal ganglia and switching motor programs. In: The Basal Ganglia. Structure and Function, (McKenzie JS, Kemm RE, Wilcock LN, eds), pp 513-544. New York: Plenum Press.

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