Supplementary Material

Implicit Motor Sequence Learning in People with Mild to Moderate Parkinson's Disease: Behavior and Related Brain Function

The study's OSF page

https://osf.io/abprn/

Details on the sample

The participants were recruited in four waves from 2018 to 2019 via local newspaper advertisements and through the Swedish Parkinson Association. Fourteen participants with PD did not perform the SRTT in the MRI scanner for different reasons: dropped out before MR assessment (n = 2), possibly incompatible implants/metal splitter (n = 5), pain/discomfort (n = 3) and head did not fit in coil/no room for the mirror showing the tasks (n = 4).

Details on the brain atlases and masks used

The automated anatomical atlas 3 [34] was used to create masks for the extraction of data from the striatum and the hippocampus. The Human Motor Area Template atlas [35] was used to create masks to extract data from the primary motor cortex. The Stanford FIND lab's 90 fROI atlas [36] was used to create a mask to extract data from the DLPFC. The brain masks used can be found on the study's OSF page.

The awareness questionnaire

A score (maximum of six points) was derived from questions about the participants' experience of (a) the non-random nature of the trials ("I believe the grey circles occurred in random locations, I did not notice a pattern" (0 points), "I think the locations of the grey circles could have followed a pattern, but I am unsure" (1 point), "I am pretty sure the locations of the grey circles were not random, but I am not sure what the pattern was" (2 points), " I am pretty sure the locations of the grey circles were not random, and I think I know what pattern they followed" (3 points), " I am sure the locations of the grey circles were not random, and I am sure I know what pattern they followed"(4 points)) and (b) the description of the regularity across

blocks ("A pattern was repeated over and over again" (1 point), "A pattern was occasionally repeated" (2 points), "Some locations occurred more often than others" (0 points).

Supplementary Table 1. Reported awareness of the sequence. 11 participants with PD had no awareness score due to dropout and are included in the "No answer column".

	No answer (%)	No pattern (%)	Could be a pattern, unsure (%)	Might be a pattern, do not know pattern (%)	Think there is pattern, probably know pattern (%)	There is a pattern, know the pattern (%)	Awareness score median (iqr)
PD (n = 57)	21.1	36.8	19.3	17.5	5.3	0	2 (1.5)
Healthy (n = 34)	0	38.2	32.4	26.5	2.9	0	2 (1.5)

The primary MLM analysis of reaction time

This analysis includes only those who had MRI data.

Supplementary Table 2. Estimates of the primary MLM analysis.

	b (95% CI)	p
Intercept	605 (583.5, 626.4)	<0.001
Trial number	0.2 (0.2, 0.2)	<0.001
Block	-14.2 (-18.2, -10.2)	<0.001
Group	-71.4 (-106.2, -36.6)	<0.001
Block x Group	-9.9 (-15.9, -3.9)	0.001

b unstandardized estimate. Degrees of freedom are not reported as the calculation is controversial and error-prone for multilevel models.

The sensitivity MLM analysis of reaction time

This analysis includes all those who performed the SRTT, inside or outside the scanner. This increased the sample size to 102 participants (68 participants with PD). The results are in line with the primary analyses and included a significant interaction of group and block type indicating that the PD group showed a lower level of implicit motor sequence learning than the healthy group, as measured by RT (Supplementary Table 3).

Supplementary Table 3. Estimates of the sensitivity MLM analysis.

|	b (95% CI)	p
Intercept	597.2 (577.1, 617.3)	<0.001
Trial number	0.2 (0.2, 0.2)	<0.001
Block	-15.2 (-18.8, -11.6)	<0.001
Group	-62.9 (-97.4, -28.4)	<0.001
Block x Group	-8.8 (-14.6, -3)	0.003

b unstandardized estimate. Degrees of freedom are not
reported as the calculation is controversial and error-prone
for multilevel models.

Descriptive data of the reaction time outcome for the two Hoehn & Yahr stages
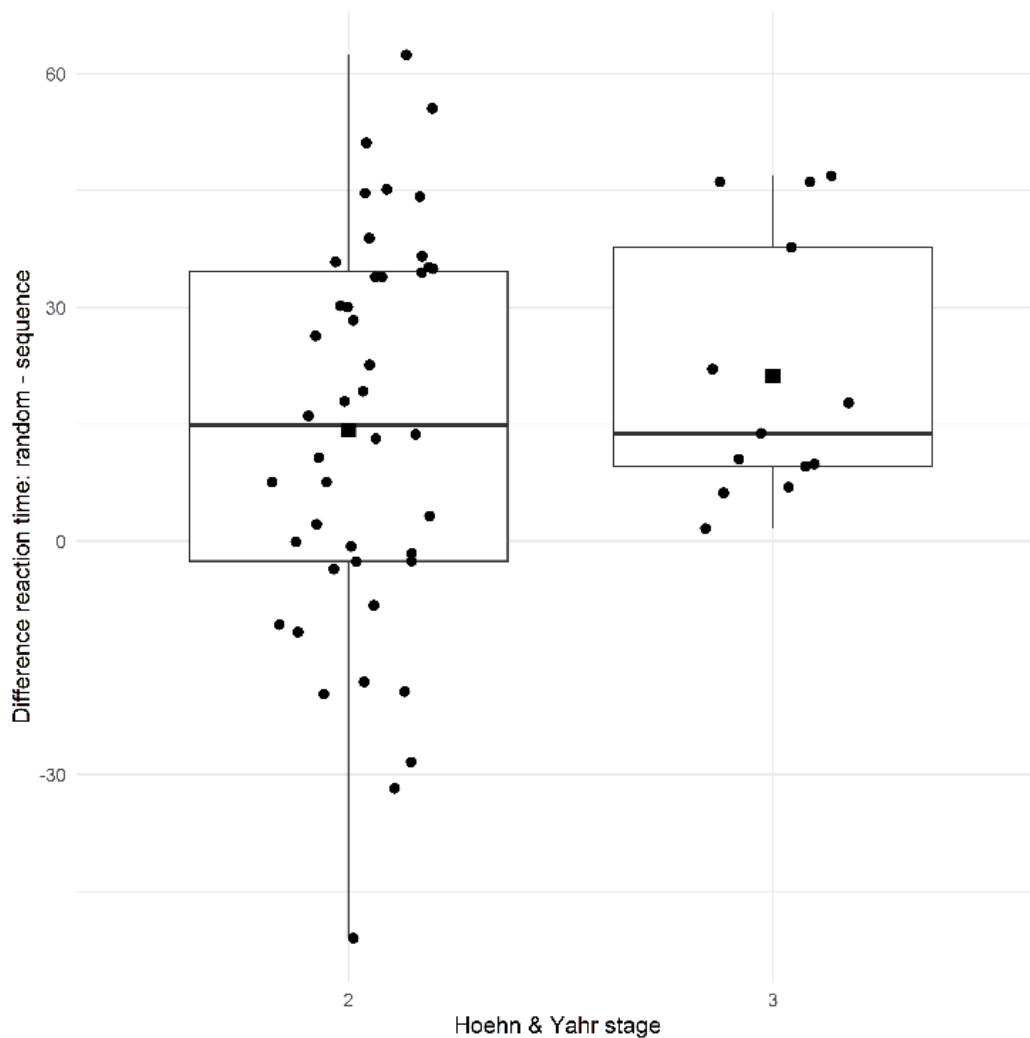
**Supplementary Figure 1. The reaction time outcome of the SRTT dependent on Hoehn &
Yahr stage.** A value above zero indicates implicit sequence learning as measured by lower RTs
for the sequence blocks compared to the random blocks. The boxplots show the median (the
line), the mean (the square), the 25th and 75th percentiles (the hinges), and the range from the
smallest to the largest value if not exceeding 1.5 times the interquartile range (the whiskers).

Descriptive data of the reaction time outcome in relation to medication level
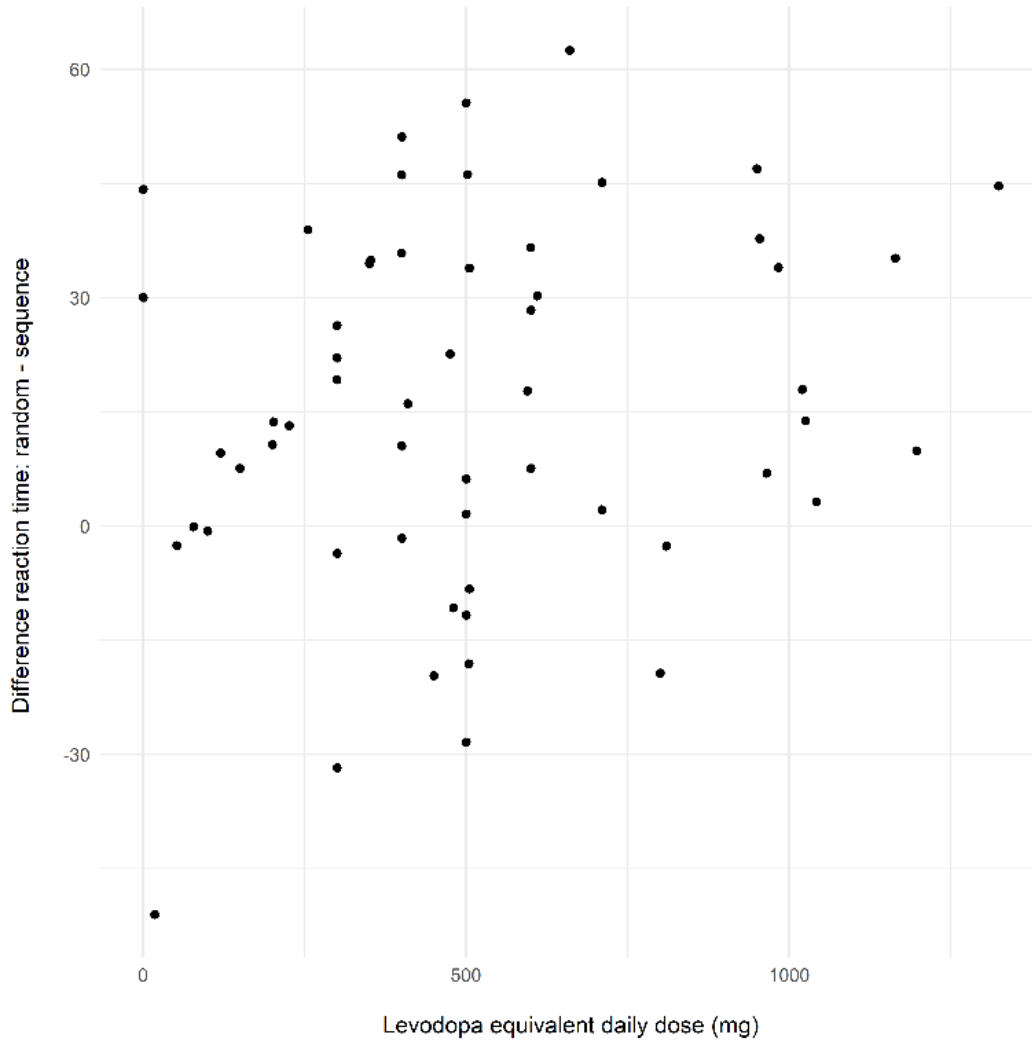
Supplementary Figure 2. The reaction time outcome of the SRTT plotted against the levodopa equivalent dose. A value above zero on the y-axis indicates implicit sequence learning as measured by lower RTs for the sequence blocks compared to the random blocks.

Descriptive data of the reaction time outcome for the SRTT parts

Supplementary Table 4. Reaction time over the course of the SRTT.

| | PD | | | HC | | |
	Sequence median (siqr)	Random median (siqr)	Difference random - sequence	Sequence median (siqr)	Random median (siqr)	Difference random - sequence
Part 1	567.61 (112.19)	567.89 (111.52)	0.28	517.10 (83.91)	517.41 (91.78)	0.31
Part 2	600.83 (116.71)	600.85 (116.76)	0.02	517.43 (91.65)	533.98 (97.37)	16.55
Part 3	617.00 (118.52)	650.48 (123.49)	33.48	534.31 (91.68)	567.05 (99.11)	32.74

Part 1: random trials from blocks 1 and 4 and sequence trials from blocks 2 and 3, Part 2: random trials from blocks 4 and 7 and sequence trials from blocks 5 and 6, Part 3: random trials from blocks 7 and 10 and sequence trials from block 8 and 9.

Functional connectivity outcomes within the healthy group

Supplementary Table 5. Functional connectivity during the SRTT within the healthy group.

	Primary motor cortex - Striatum	Primary motor cortex - Cerebellum, motor parts	Primary motor cortex - Hippocampus	Primary motor cortex - DLPFC
t	0.20	-2.21	1.57	-0.71
p FDR	0.86	0.35	0.53	0.75

Functional connectivity measures when contrasting the conditions (sequence-random blocks).