

TECHNOLOGICAL ASSESSMENT AND RESTING-STATE FMRI CORRELATES

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OBJECTIVES

Handwriting impairments are frequent and disabling in people with Parkinson's disease (pwPD), but their evaluation remains challenging. Neural correlates underlying these alterations are still poorly understood. This study aimed to assess handwriting alterations in pwPD compared to healthy controls (HC) and to identify the functional neural correlates of handwriting deficits using resting-state functional connectivity (RS-FC) analysis.

MATERIALS

Forty pwPD and 30 age- and sex-matched HC were included (Table 1).

METHODS

Included subjects underwent handwriting and hand dexterity assessments, neuropsychological evaluation, and RS-functional MRI. A tablet-based handwriting assessment included four tasks: Systematic Screening for Handwriting Difficulties-SOS test (copying a text), funnel test (coloring a shape), closed loop task (drawing specific symbols), and repetitive cursive loop task (writing repeated symbols). SOS test was executed also on paper. RS-fMRI data were analyzed using independent component analysis and compared between groups. Correlations between clinical measures and RS-FC were explored in pwPD.

RESULTS

Compared to HC, pwPD showed smaller word size, slower drawing speed, and poorer performance in the tablet handwriting tasks (Fig. 1). SOS test on paper confirmed slower writing speed, smaller size, and lower writing quality in pwPD (Table 2). RS-FC analysis revealed decreased connectivity in the basal ganglia, cerebellum, ventral default mode, and visual networks, alongside increased RS-FC in the salience and executive control networks in pwPD relative to HC (Fig. 2). Smaller writing amplitude and poorer handwriting quality were associated with altered RS-FC in motor and cognitive networks (Fig. 3).

Table 1 - Sociodemographic and clinical variables

	HC (N = 30)	pwPD (N = 40)	p pwPD vs HC
Age [years]	65.6 ± 6.3 (53.7; 78.5)	65.5 ± 7.6 (51.0; 80.3)	1.00
Sex [M/F]	21/9	26/14	1.00
Education [years]	14.6 ± 4.0 (5; 27)	11.7 ± 3.5 (5; 21)	0.002
PD duration [years]	-	4.1 ± 3.5 (0.5; 17.0)	-
LEDD [mg]	-	421.2 ± 270.4 (0; 1090)	-
H&Y ON [1/1.5/2/2.5]	-	1/2/1/35/1	-
MDS-UPDRS-III ON	-	28.3 ± 8.2 (13; 49)	-
MMSE	29.2 ± 0.8 (28; 30)	29.2 ± 1.0 (24; 30)	0.62

Table 2 - SOS test on paper HC vs pwPD

SOS on paper	HC (N = 15)	pwPD (N = 35)	p pwPD vs HC
SOS five-minute test - speed [letter/min]	552.9 ± 96.3 (387; 750)	408.0 ± 110.3 (210; 700)	0.001
SOS five-sentence test - Average letter size [mm ²]	3.2 ± 0.5 (2.4; 4.2)	2.7 ± 0.8 (1.66; 4.27)	0.02
SOS five-sentence test - Fluency [0/1/2]	10/5/0	5/15/15	<0.001
SOS five-sentence test - Regularity letter size [0/1/2]	2/3/10	0/2/33	0.02
SOS five-sentence test - SOS score [0-10]	3.1 ± 0.6 (2; 8)	5.9 ± 1.3 (4; 9)	0.02

Fig. 2 - Brain functional connectivity in pwPD vs HC

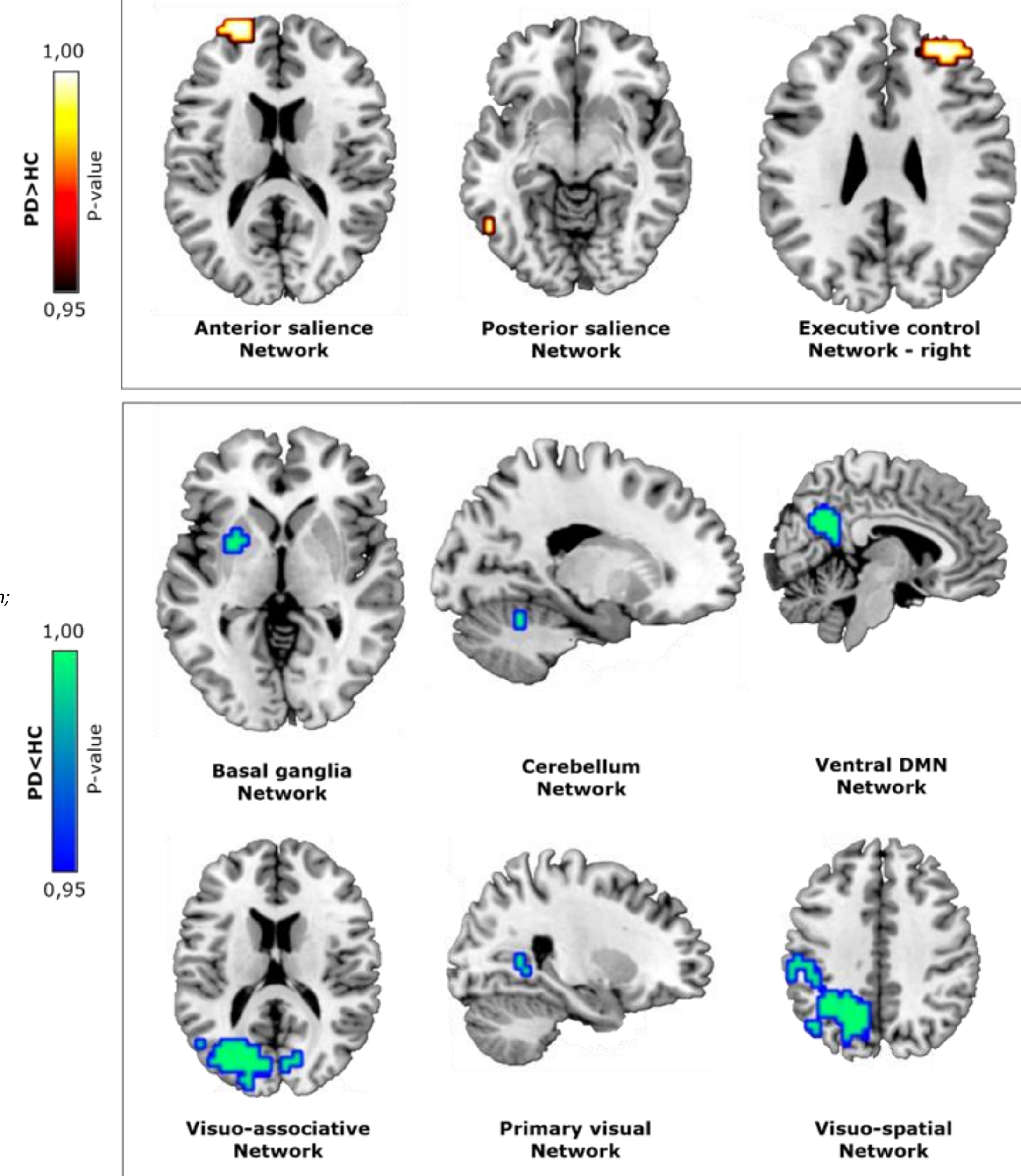


Fig. 1 - Representation of handwriting tasks on tablet

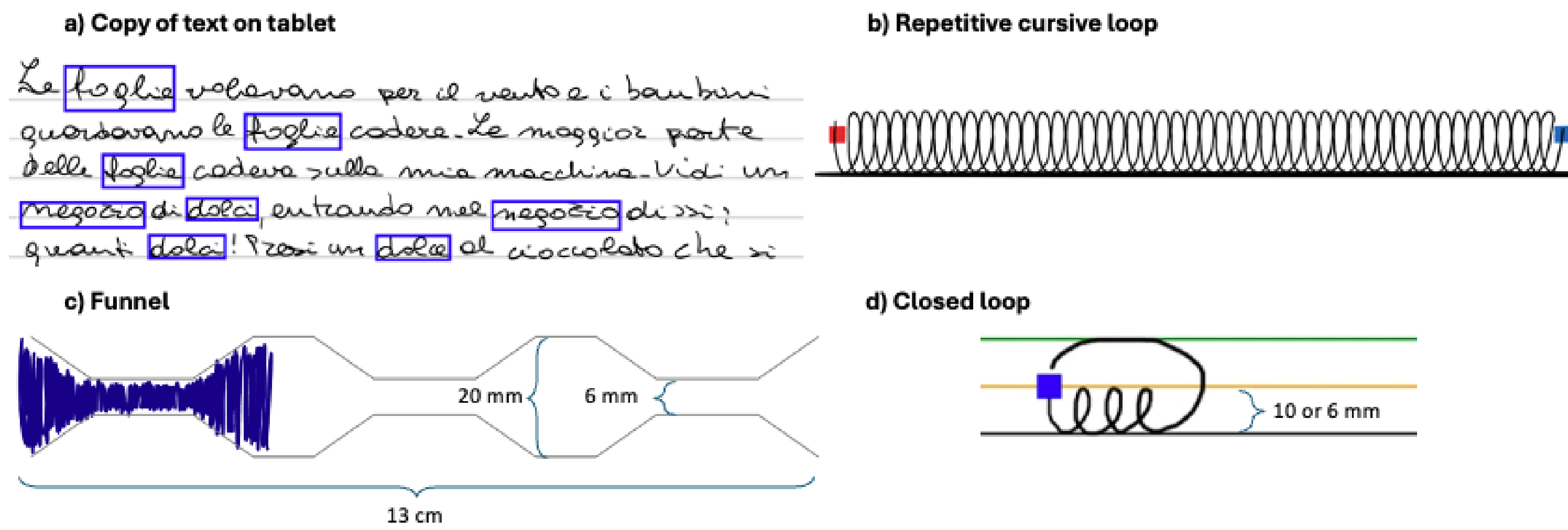
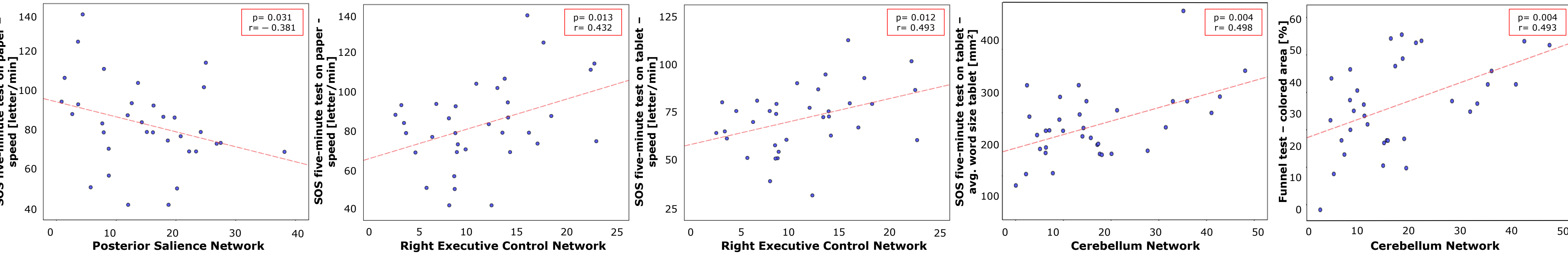


Fig. 3 - Correlations between RS-FC and significantly different handwriting variables in pwPD vs HC



DISCUSSION

PwPD exhibited handwriting impairments that were correlated with RS-FC changes in motor and cognitive networks, highlighting the neurological basis of handwriting difficulties in pwPD.

CONCLUSIONS

These findings underscore the multifaceted nature of handwriting deficits in pwPD, emphasizing the need for future studies investigating the effects of specific handwriting rehabilitation strategies on clinical, kinematic and MRI parameters.