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Interpreting spatial dysgraphia after stroke: straight-ahead of straight above?

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Introduction

Spatial dysgraphia, frequently observed after a right hemisphere stroke (1), associates signs of spatial compression in relation to spatial neglect, and a tilted writing which remains to be explained. Here we present a case study showing that tilted writing is due to a tilted representation of the vertical.

Materials and Methods

Case presentation

JW was a 75 year-old male, right-handed, who underwent a hemorragic right hemisphere stroke causing a total left hemiplegia with pronounced hemianesthesia, left hemianopsia and signs of unilateral spatial neglect (UNS). At entry, balance disorders were particularly severe, with a pusher syndrome. Stroke also induced a spatial dysgraphia characterized by a counterclockwise tilt of the writing lines (Fig. 1).

Handwriting evaluation

- Tasks: Copy of the 5 first lines of the BHK test, at M3 and M9, and after modulation of verticality representation (M3). Several types of cueing were tested: blank paper (reference condition) and spatially indexed paper (12° or 24 upwardly or downwardly sloping lines).
- Parameters analysed: inclination of each writing line in respect to Earth vertical (°) or to the cueing lintes, inclination of the left-hand margin in respect to the Earth vertical, and the mean time to write a letter (sec).
- Statistics: comparison of JW's results with a peered healthy participant (JB).

Representation of the verticality

- Postural vertical (VP) [2]
- Visual vertical (VV) [3]

UNS

Modulation: tilt for 10 minutes at 30° in the dark

le suis bien le suis de leau le vois de le au mais je ne sais pas

Figure 1. Sample of JW's handwriting at M3 on blank paper.

Body and non-body UNS evaluation using a battery of well-known tests.

	JB	JW-M3	JB vs. JW-M3	JW-M9	JB vs. JW-M9	JW-M3 vs. JW-M9
Blank paper			p		p	p
median (°) IQR (°)	-2.1 1.2	-9.4 4.6	0.008*	-8.8 1.4	0.008*	0.08
Lines down 24°						
median (°) IQR (°)	-0.9	-10.2 5.7	0.008*	-8.2 3.5	0.008*	0.548
Lines down 12°						
median (°) IQR (°)	-1 1.7	-3.5 3.9	0.008*	- 4.4 1.9	0.008*	0.89
, ,	,	3.3		1.3		
Lines up 12°						
median (°) IQR (°)	0 0.7	-1.8 2.1	0.016	- 0.6 1	0.016	0.08
	0.7	۷. ـ		_		
Lines up 24°						
median (°)	-1.1	-0.3	0.548	-1	0.222	0.04
IQR (°)	1.4	1.2		1.1		

Table 1. Inclination of JW's writing lines at M3 and M9 in the different	
conditions.	

	JB	JW-M3	JB vs. JW-M3	JW-M9	JB vs. JW-M9	JW-M3 vs. JW-M9
Tilt of the left-han median (°) IQR (°)	d margin -0.1 2.2	-9.4 4.6	p 0.008*	-8.5	p 0.008*	p 0.416
Angle between the median (°) IQR (°)	e margin a 92	and the writ 90 2	o.102	91	0.129	1

Table 2. Tilt of JW's left-hand margin and writing orthogonality at M3 and M9 in the 'blank paper' condition.

	JB	JW-M3	JB vs. JW- M3	JW-M9	JB vs. JW- M9	JW-M3 vs. JW-M9
Blank paper			p		p	р
median (sec/lett)	0.9	1.7	0.008*	0.9	0.548	0.008*
IQR (sec/lett)	0.3	0.7	0.000	0.4	0.540	0.000
Lines down 24°						
median (sec/lett)	0.7	1.5	0.008*	0.8	0.151	0.008*
IQR (sec/lett)	0.2	0.2	0.008	0.3	0.151	0.008
Lines down 12°						
median (sec/lett)	0.7	1.4	0.008*	0.8	0.222	0.008*
IQR (sec/lett)	0.3	0.8	0.008	0.2	0.222	0.008
Lines up 12°						
median (sec/lett)	0.7	1.4	0.016	0.9	0.095	0.008*
IQR (sec/lett)	0.3	0.7	0.016	0.2	0.095	0.008
Lines up 24°						
median (sec/lett)	0.7	1.1	0.032	0.8	0.222	0.222
IQR (sec/lett)	0.3	0.5	0.032	0.4	0.222	0.222

Table 3. JW's handwriting speed at M3 and M9 in the different conditions.

C	modulation	modulation		
Postural vertical			р	
mean (°)	-9.8	0.6	0.001*	
SD (°)	3.6	3.7	0.001	
Writing lines inclination			p	
median (°)	-9.4	-5.2	0.043*	
IQR (°)	4.6	2.7	0.043	
Tilt of the left-hand margin			p	
median (°)	-9.4	-3.2	0.008*	
IQR (°)	4.6	4.4	0.000	
Angle b/w the margin and the writing lines			p	
median (°)	90	92	0.279	
IQR (°)	2	1	0.275	
Writing speed			p	
median (sec/lett)	1.7	0.9	0.008*	
IQR (sec/lett)	0.7	0.1	0.000	

Table 4. Spatial and temporal features of JW's handwriting after verticality normalization.

- Inclination of handwriting lines on blank paper and downward sloping lines, both at M3 and M9 (Tab.1)
- No significant line inclination on upwardly sloping lines (Tab.1)
- Inclination of the left-hand margin on blank paper at M3 and M9 and conservation of the orthogonality (Tab.2)
- Writing speed slower than the healthly subject at M3 but no lonter at M9 (Tab.3)
- Signs of UNS at M3 but not M9 (not shown)
- Verticality representation: altered at M3 and M9 (not shown)
- Lines inclination, margin tilt and writing speed clearly improved after PV normalization (Tab.4)

Discussion and Conclusion

At 3 months, JW's handwriting was slow and presented an upward tilt and an increased left-hand margin due to a global tilt of his orthogonal scheme. The spatial features of his handwriting were maintained 9 months after stroke, while his writing speed was normalized. JW's handwriting inclination was neither related to spatial neglect nor to a rotated straight-ahead, but was clearly improved by a transient modulation of JW's verticality perception.

After stroke, a tilted handwriting may thus be due to a tilted representation of the vertical.

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