Investigating Age-related Changes in Inhibition and the Role of the Left DLPFC using High-frequency TMS

Lolansen, C.[A], Badham, S. P.[B], Mitra, S.[B], & Howard, C. J.[B]
[A] *University of Nottingham, School of Psychology, East Dr, Nottingham NG7 2RD, United Kingdom*
[B] *Nottingham Trent University, Department of Psychology, 50 Shakespeare Street, Nottingham NG1 4FQ, United Kingdom*

Background

- Ageing is associated with frontal lobe deterioration and decline of cognitive functions[1]. Inhibition, the ability to selective attend to information and control responses, involves the DLPFC [2] and is known to decline across the age-span[3].
- TMS has causally implicated the left DLPFC in inhibition performance[4].
- Research suggests that there may be distinct neurological underpinnings for different forms of inhibition[5].
- However, it is still not clear:
  - What these distinct forms of inhibition consists of
  - If they are differentially modulated by ageing
- This study explores i) the contributions of the left DLPFC to age-related changes in inhibition and ii) whether this can reveal distinct forms of inhibition when comparing different inhibition tasks.

Method

Design

This study used a mixed 2x2x2x2 design. Between factors were age (young vs older adults) and stimulation (20 Hz vs sham) and the within-factors were task (Simon vs Stroop) and congruency (congruent vs incongruent). The study measured RT (msec) and accuracy (total correct responses).

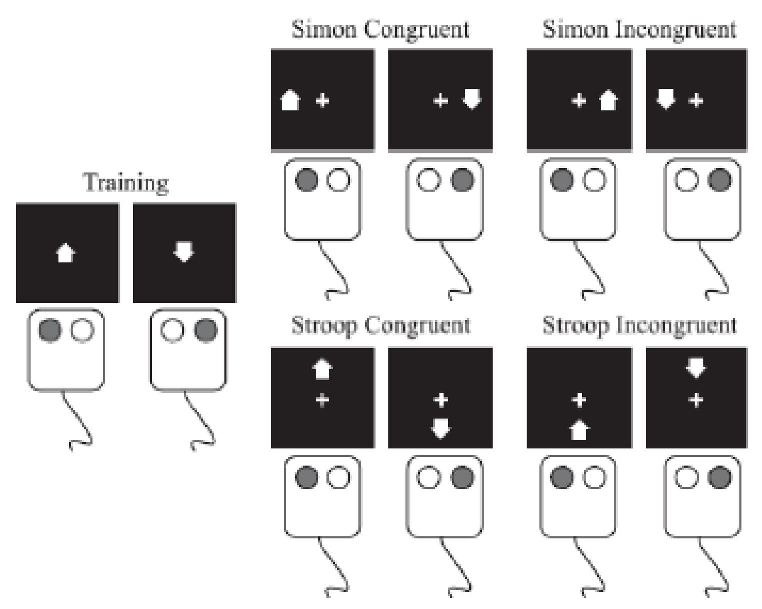
Participants

A total of 44 participants were recruited, 22 healthy young adults (*M* age = 21.25, *SD* = 2.61, 6 males, 16 females) and 22 healthy older adults (*M* age =, 70.52, *SD* = 5.63, 11 males, 11 females).

Materials

All participants completed demographics questions, a self-rated health questionnaire, and the GDS[6]. Older adults additionally completed the SMMSE[7]. All of these were completed on paper.

The experimental task was a combined Simon and spatial Stroop task and presented digitally on a computer screen. The main experimental block consisted of 80 trials.



Note. This figure was taken from "Common and distinct neural substrates of attentional control in an integrated Simon and spatial Stroop task as assessed by event-related fMRI" by Liu et al. (2004), *Neuroimage, 22,* p. 1100.

TMS Protocol

The TMS coil was positioned using Visor2 neuronavigation software in conjunction with craniometric measures. These were used to morph a generic MRI image onto each participant's key craniometric measures. The coil was positioned above the left DLPFC using Talairach coordinates (x = -35, y = 24, z = 48). For sham stimulation, the coil was angled 90° away from the scalp surface. The stimulation was 20 Hz online stimulation (set to 90% of RMT), applied synchronously with the onset of participants pressing the SPACE bar to start the next trial.

Procedure

Then participants completed a TMS safety screening, demographic questionnaire, self-rated health questionnaire, and the GDS. Older adults completed the SMMSE.

Results

All trials above 2500 msec RT were excluded (14 out of 3600). Descriptives in Table 1.

Accuracy

A mixed 2x2x2x2 ANOVA (young vs old, TMS vs sham, Simon vs Stroop, congruent vs incongruent) revealed:

- Older adults were more accurate than young adults ($p = .002$)

Response time

A mixed 2x2x2x2 ANOVA (young vs old, TMS vs sham, Simon vs Stroop, congruent vs incongruent) revealed:

- Older adults were significantly slower than young adults ($p < .001$)
- Participants who received TMS were significantly faster than those who received sham ($p = .035$).
- No main effect of task ($p = .350$) or congruency ($p = .464$).
- Interaction between age and task type ($p = .015$). The interaction showed that the age difference was smaller on the Stroop task than the Simon task (see Figure 2).

Figure 2

Line Graphs Showing the Estimated Marginal Means for Mean RT on the Simon and Stroop Tasks for Young and Older Adults. Error Bars Represent the 95% CI.

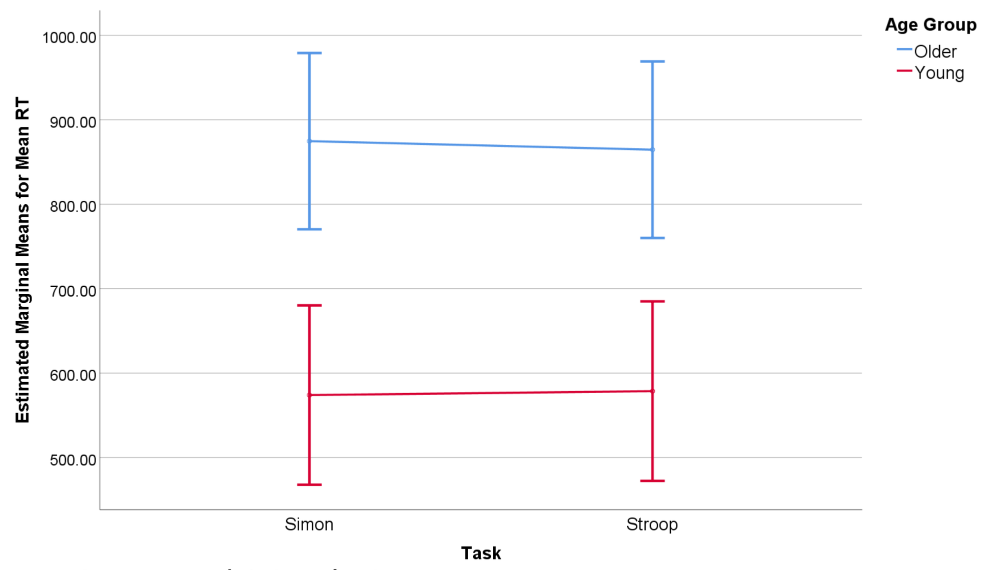


Table 1

Descriptives for RT Separated by Age Group and Stimulation

	Young adults				Older adults			
	Sham		TMS		Sham		TMS	
	M	SD	M	SD	M	SD	M	SD
Average RT	661.72	307.73	490.86	94.21	954.35	282.77	784.97	184.75
Simon congruent	655.22	305.21	492.56	91.76	951.42	275.90	792.44	198.84
Simon incongruent	661.14	308.06	487.25	100.20	959.41	284.49	795.58	190.18
Stroop congruent	661.80	331.21	488.99	95.34	952.86	281.83	776.56	182.45
Stroop incongruent	668.69	308.81	494.92	95.88	953.70	293.89	775 .29	171.13

Discussion

- Older adults being both more accurate and slower than young adults could reflect a speed-accuracy trade-off, which is consistent with the literature[8].
- TMS facilitated performance for both groups, demonstrating the efficacy of 20 Hz online stimulation for enhancing inhibition.
- No significant interaction between age and stimulation suggests that young and older adults' performance was modulated to similar degrees by stimulation.
- Only the left DLPFC was stimulated in this study. Future research could stimulate both hemispheres to explore whether age-related differences in effects of stimulation is expression in lateralisation differences
- Age difference was smaller for the Stroop task compared to the Simon task, but this did not interact with stimulation.
- Further investigation required to elucidate if the two tasks are only behaviourally different with similar support from the DLPFC.

References

1 West, R. L. (1996). An application of the prefrontal cortex theory to cognitive ageing. *Psychological Bulletin, 120,* 272-292.
2 Mathis, A., Schunck, T., Erb, G., Namer, I. J., & Luthringer, R. (2009). The effect of aging on the inhibitory function in middle-aged subjects: A functional MRI study coupled with a color-matched Stroop task. *International Journal of Geriatric Psychiatry: A Journal of the Psychiatry of Late Life and Allied Sciences, 24(10),* 1062-1071.
3 Andrés, P., & Van der Linden, M. (2000). Age-related differences in supervisory attentional system functions. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 55(6),* P373-P380.
4 Vanderhasselt, M. A., De Raedt, R., Baeken, C., Leyman, L., & D'haenen, H. (2006). The influence of rTMS over the left dorsolateral prefrontal cortex on Stroop task performance. *Experimental Brain Research, 169,* 279-282.
5 Liu, X., Banich, M. T., Jacobson, B. L., & Tanabe, J. L. (2004). Common and distinct neural substrates of attentional control in an integrated Simon and spatial Stroop task as assessed by event-related fMRI. *Neuroimage, 22,* 1097-1106.
6 Yesavage, J. A., Brink, T. L., Rose, T. L., Lum, O., Huang, V., Adey, M., & Leirer, V. O. (1983). Development and validation of a geriatric depression screening scale: a preliminary report. *Journal of Psychiatric Research, 17,* 37-49.
7 Molloy, D. W., Alemayehu, E., & Roberts, R. (1991). Reliability of a standardized mini-mental state examination compared with the traditional mini-mental state examination. *American Journal of Psychiatry, 148*, 102-105.
8 Smith, G. A., & Brewer, N. (1995). Slowness and age: Speed-accuracy mechanisms. *Psychology and Aging, 10(2),* 238–247.