Fast sensorimotor learning in middle-aged adults

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Introduction

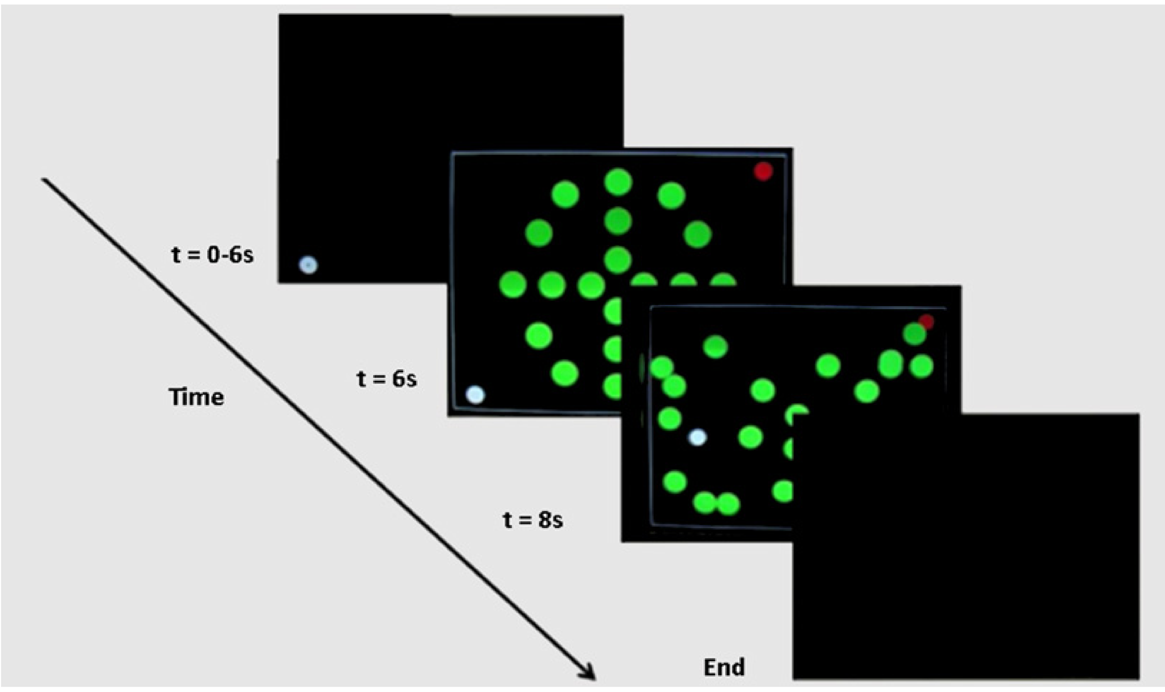
- Motor learning and performance are closely related to control processes, and deteriorate with age (Ren et al., 2013)
- The aim of this experiment was to investigate functional and microstructural brain differences following acquisition of a motor skill task that involved perceptual and cognitive processes in middle-aged participants

Methods

Participants (N =21)

- Right handed
- 11 female
- Aged 40-50 (M = 45.2 +/- 3.1)

Figure 1. Multiple Moving Objects (MMO) Task



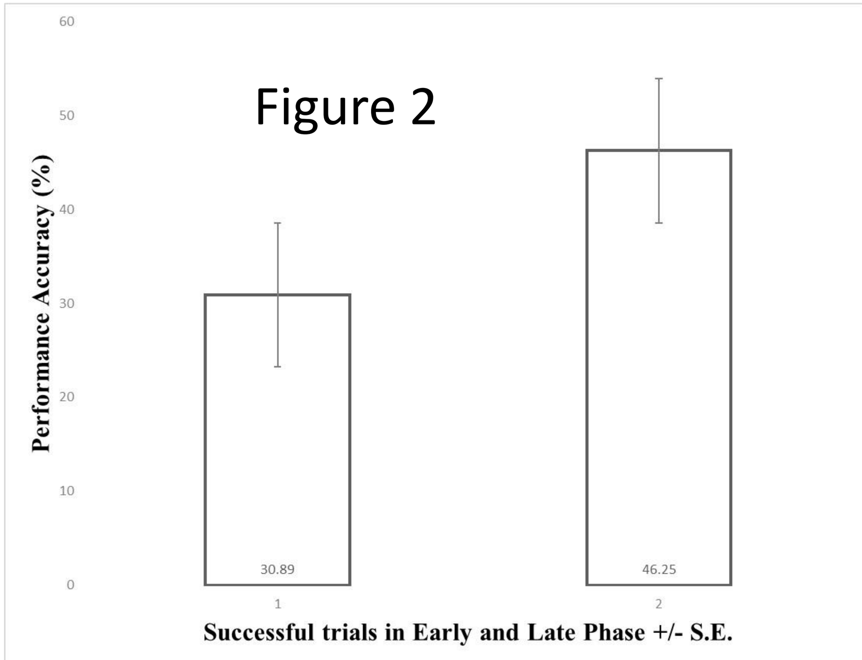
- 20 green objects moving in 8 linear trajectory patterns in pseudorandom order (Bennet et al., 2018)
- Fibre-optic MRI-compatible mouse (FOM-2B-10B, NAtA technologies, Canada) to control the white cursor on the screen until it reached the red target while avoiding the green objects
- Siemens Magnetom Avanto 1.5-T MRI scanner with a 32-channel phased-array head coil
- Each session included: a BOLD fMRI Run 1 (15 min) (Early Learning phase), structural MPRAGE (6 min) (Middle Practice phase), diffusion scan using NODDI multiband (8 min) (Middle Practice phase), and BOLD fMRI Run 2 (15 min) (Late Learning phase), total ~45 min
- We calculated a Learning Index (LI) to assess individual learning progress for each participant.

$$LI = \frac{\textit{Late learning score} - \textit{Early learning score}}{\textit{Late learning score} + \textit{Early learning score}}$$

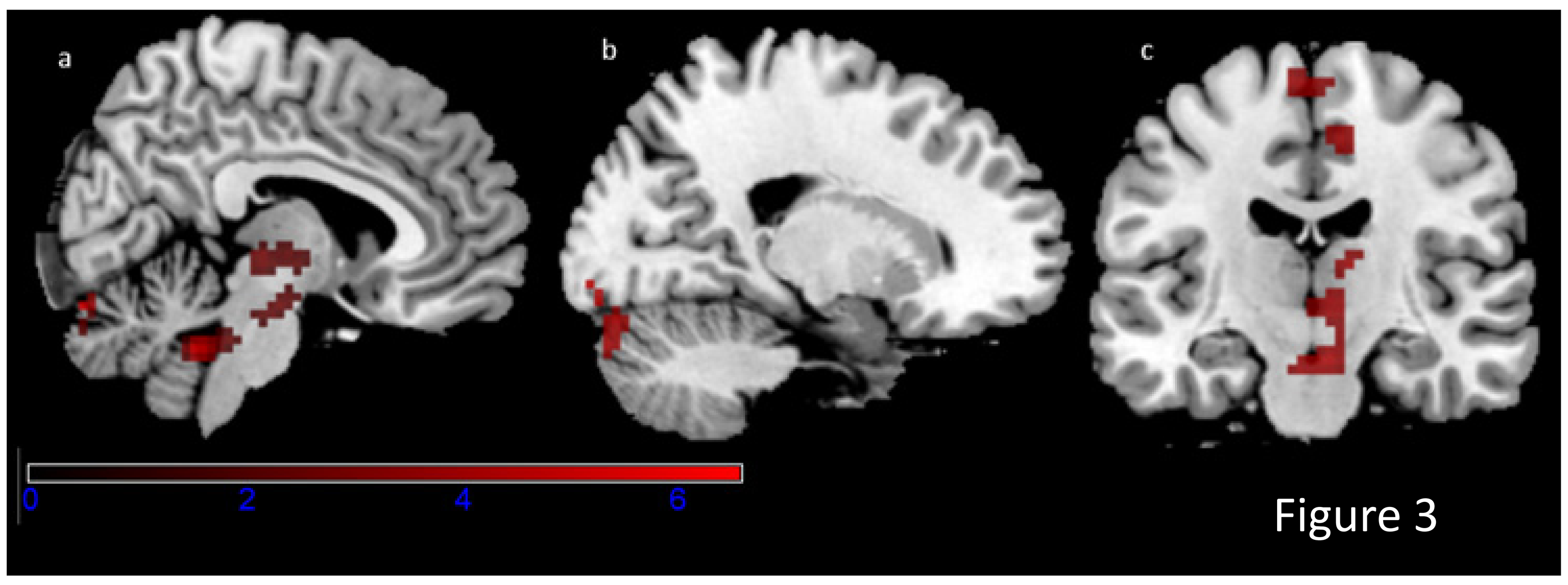
- We correlated each individual LI with the level of the reported computer game experience of each participant. We also correlated level of computer game experience and accuracy
- Whole brain fMRI analyses and NODDI analyses reported are at p<.001 and FDR corrected

Results

- We compared number of successful trials in the late learning phase (80 trials) (mean 46.25% +/- 18.23) to those in the early learning phase (first 80 trials) (mean 30.89% +/- 17.45) with a paired samples t-test, and found a statistically significant difference, $t(20) = -7.52$, $p<.001$ (Figure 2). The participants performed 72 further training trials between the early and late phases, during the structural and diffusion scanning sequences. This corresponds to a large positive effect, Cohen's d=0.88



- We correlated each LI (Learning Index) with the level of the reported computer game experience of each participant; it was not significant, r=-.235, p = .304
- We correlated the level of computer game experience and accuracy, and we found a significant and positive correlation, r=.545, p<.001
- We performed a 2x2 repeated measures ANOVA with factors: testing phase (Early, Late Learning) and Accuracy (Correct, Incorrect trials). We found a main effect of testing phase (Early vs. Late), but no effect of accuracy or interaction between testing phase and accuracy
- **Figure 3a**: Main effect of testing phase: Cerebellar Vermis, pons, R thalamus and R Lingual Gyrus. **Figure 3b**: Areas more active in Early rather than Late Learning phase included the cerebellum bilaterally (Crus 2, R Crus 1) and the R Lingual Gyrus. **Figure 3c:** Areas more active in Late rather than Early Learning phase were the Cerebellar Vermis, pons, R thalamus, R Mid Cingulate Cortex, R post. Medial Frontal Gyrus, and L Paracentral Lobule



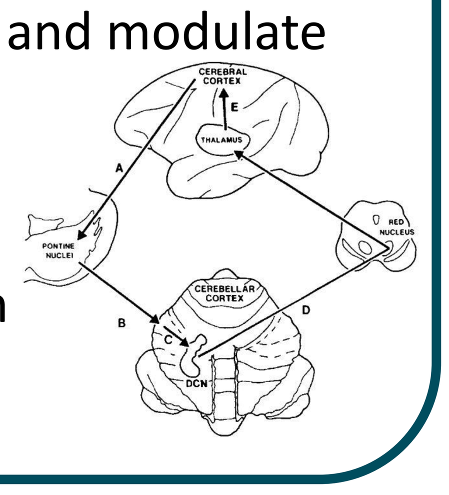
- **Table 1.** Areas with significant positive correlation of the Learning Index and BOLD activity

Brain Area	r	p
Putamen	0.493	0.023
Pons	0.551	0.010
Anterior Cingulate	0.524	0.015
Postcentral gyrus	0.437	0.047

- Correlations between the LI and NODDI indices: FA (fractional anisotropy), MD (mean diffusivity), ND (neurite density), and ODI (orientation dispersion index) revealed a negative correlation of the LI and FA in the SMA; a negative correlation of the LI and MD in the cerebellum and middle temporal gyrus; and a positive correlation of LI with ODI in the SMA

Discussion

- We report a main effect of testing phase in the cerebellum, the pons, the thalamus and the lingual gyrus. The activation of the lingual gyrus (middle occipitotemporal area) is congruent with findings that show its activation enhanced when visual and tactile information are combined to strengthen the representation of the visual stimulus (Macaluso et al., 2000), suggesting back projections from multimodal convergence areas can feedback and modulate representations in a primary modality (Driver & Spence, 2000).
- The activations of the cerebellum, pons and thalamus fit the model of feedforward and feedback limbs of the cerebrocerebellar circuit proposed by Schmahman (2001) in the context of a task that requires integration of associative, sensory and motor learning. The model posits that this information is transmitted by the corticopontine pathway, while the feedback route carries the information back from the cerebellum to the thalamus via the red nucleus. The thalamic projections to associative, motor and sensory areas complete the circuit.



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