

Different neural networks during memory encoding: a cross-cultural fMRI study

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Purpose. To study neural networks during non-verbal episodic learning in subjects with alike performance but different cultural upbringing. To test whether the hypothesis that alike performance indicates activation of alike neural networks holds true in a cross-cultural study.

Methods. A nonverbal episodic memory task was performed during fMRI by 14 Chinese subjects (7 f, 7 m, age 29±6 y) and 12 Caucasians (6 f, 6 m, 26±2 y). Subjects were asked to learn ten abstract visual designs. Immediately after learning, subjects had to actively recall the abstract figures. Both, learning and retrieval were repeated five times. fMRI imaging during learning was performed at 1.5 T (Siemens Magnetom Vision). Data were processed and analysed by means of Statistical Parametric Mapping (SPM99). For each subject and block, contrasts were calculated between active and rest epochs. This resulted in five individual contrast images for the five learning blocks. Group comparisons were computed by means of two-sample t-tests on the contrast images (random effects model). Dorsal and ventral areas involved in repetitive episodic learning were masked to calculate effect sizes of different ventral and dorsal regions and to compare these between groups (Fig. 2).

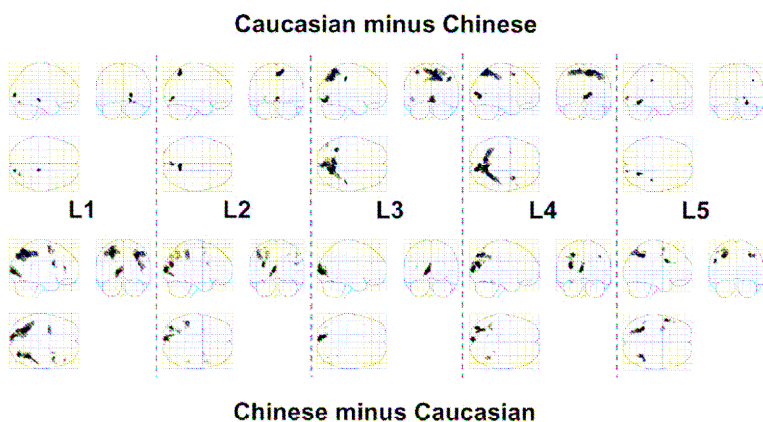


Fig. 1. Group differences at each of the five learning blocks L1 to L5 on glass brain views. Neurologic convention – left is left on coronal, left is top on axial views.

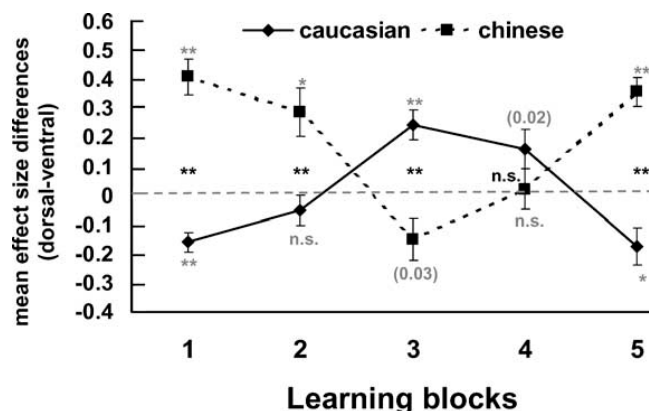


Fig. 2. Dorsal minus ventral mean difference scores of groups over repetition. Significant between-group differences indicated by black asterisks. Details see text.

Results. Performance was statistically proven to be alike between groups. Activations calculated by single-tailed group comparisons are shown in Fig. 1. During first learning (L1) Caucasians showed superiority of inferior occipital areas and right hippocampus whereas the opposite contrast exhibited significantly increased activations of biparietal and bifrontal cortex in the Chinese group. During the next two learning blocks (L2 and L3) this difference pattern decreased and reverted at the fourth learning block (L4). Interestingly, this effect did not evolve further as the fifth learning block (L5) reflected rather the same difference map as L1. These changes could be further demonstrated by a MANOVA for repeated measures on mean effect size differences for dorsal and ventral regions which again yielded a highly significant group-by repetition interaction (Fig. 2). Tests on statistical significance of within-group differences of dorsal minus ventral activity showed significantly higher ventral than dorsal activity in the Caucasian group during the first learning block (L1, indicated by grey asterisks) whereas at L3 there was significant dorsal superiority. At L4 there is again a decrease of dorsal activation ($p=0.02$, n.s. under Bonferroni correction). At L5 the Caucasian group showed a negative dorsal minus ventral difference as for L1. Rather the reversed pattern was observed for the Chinese group. Although the within-group difference at L3 was not significant for the Chinese group (according to Bonferroni-adjusted values $p=0.03$), the between-group difference was highly significant. No significant group difference emerged at L4. At L5 the Chinese group demonstrated again significant dorsal superiority.

Conclusions. Despite of alike behavioural performance, significant differences of underlying neural substrate were observed between groups of persons brought up in ideographic (Chinese) or phonographic (German) language system. The equivalent performance in both groups means that differences in neural involvement indicate different processing routines to accomplish the same task with the same result. On initial learning a bilateral frontal and bilateral parietal cortical network predominated in Chinese subjects. By contrast, initial learning in Caucasian subjects is preferentially achieved with activation of posterior ventral regions. With repetitive learning and recall of this task a shift is observed when comparing both groups. Irrespective of behavioural performance cultural imprinting of neural substrate extends beyond language-related cognition and determines spatial and object-related processing during an episodic nonverbal memory task.