Neural evidence for a tradeoff between visuospatial working memory capacity and sensitivity to task irrelevant information

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Background

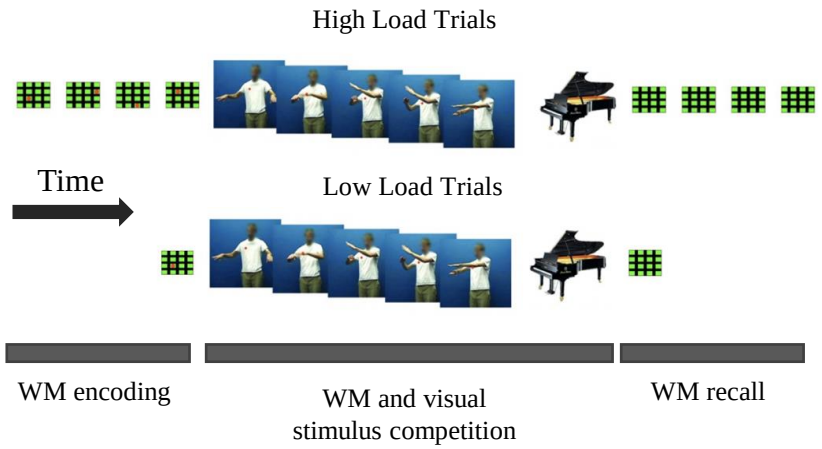
Successful working memory performance is predicated on the ability to use attentional resources to suppress both internal and external distractions. Here we investigate neural mechanisms that underpin online competition between visuospatial WM maintenance and external visual stimulation, and how they manifest differently across individuals who differ in WM capacity. In particular, we test how differences in the brain response to task irrelevant stimuli differ as a function of visuospatial WMC.

Methods

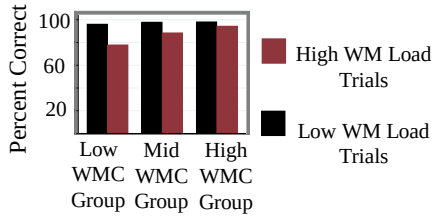
Participants (n=46; 30 females; mean age = 20.0) encoded successive dot locations in either high (4 dots) or low (1 dot) memory load trials while EEG was recorded from 29 scalp locations.

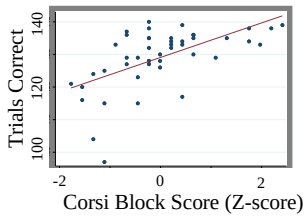
During WM maintenance, participants watched short discourse videos containing semantically congruent or incongruent speech and gesture combinations followed by picture probes related to the video's speech content.

Intervening video and picture stimuli created potential conflict between external visual stimulation and visuospatial content in memory. WMC was modeled as a continuous predictor of both ERP and ERSP effects. Presented figures associated with High (n=11) and Low (n=13) WMC subgroups were determined using offline VSWM measures (Corsi Block total score above and below 1 std dev from sample mean, respectively). Data collected from trials with inaccurate recall responses were removed from the analysis.



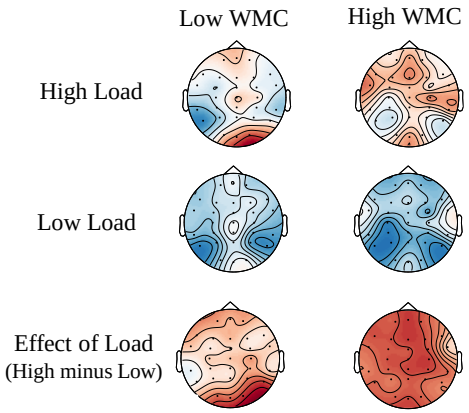
VS Recall Performance





WM Maintenance during Videos

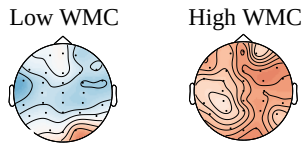
Alpha Band



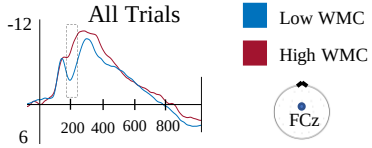
Increased WM load was associated with alpha power enhancement (Main effect Load, β=0.13dB; t=3.52)—this effect had a frontocentral distribution in those with high WMC, while it was focused in posterior channels in low WMC individuals. (Region X Corsi, Frontal: β=0.05dB, Posterior: β=-0.07dB)

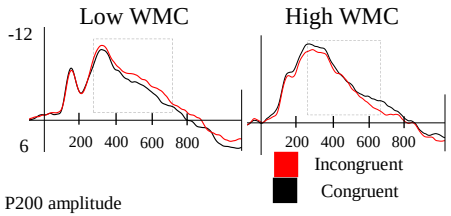
Theta Band

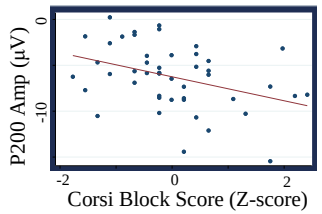
Theta enhancement as a function of WM load was greater in those with high WMC (Load X Corsi, β=0.31dB; t=9.47)



WM Maintenance and Picture Processing







Average P200 amplitude is inversely proportional to WMC (Main effect Corsi score, β=-1.32μV; t=-2.98).

Semantic congruity effects (N300/N400) were greater in high load trials (Load X Video, β=-0.26μV; t=-2.44) but were reduced in high WMC participants (Video X Corsi, β=0.28μV; t=4.06).

Conclusions

Increasing memory load resulted in alpha band enhancement during the maintenance interval in all participants, but **this effect was smaller and less broadly distributed among participants with lower WMC**. These data suggest WMC relates to differences in sensory gating mechanisms that prevent exogenous capture by visual distractors (1,2). **Theta band enhancement during the maintenance interval was less prominent in participants with lower WMC**, suggesting reduced top-down modulation of visuospatial WM activations in the face of competition from visual distractors (3)

ERPs to picture probes presented during the maintenance interval revealed larger amplitude P200 among participants with lower WMC. As visual P200 is enhanced during stimulus evaluation(4), these data indicate participants with reduced WMC were more receptive to task-irrelevant exogenous visual input. Pictures also elicited larger N300/N400 effects among low WMC participants, suggesting sensitivity to discourse information in the task-irrelevant videos was actually greater among low WMC participants than their more visuospatially inclined peers.

Differences in P200 amplitude as well as in the distribution of frontoparietal alpha activity suggest WMC is related to differences in exogenous attentional capture by task-irrelevant visual stimuli. Observed load effects on theta activity further suggests WMC relates to the efficacy of inhibitory control mechanisms mediated by frontostriatal circuits (5).

References

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