Age-related differences in working memory for order information: An fMRI study

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INTRODUCTION

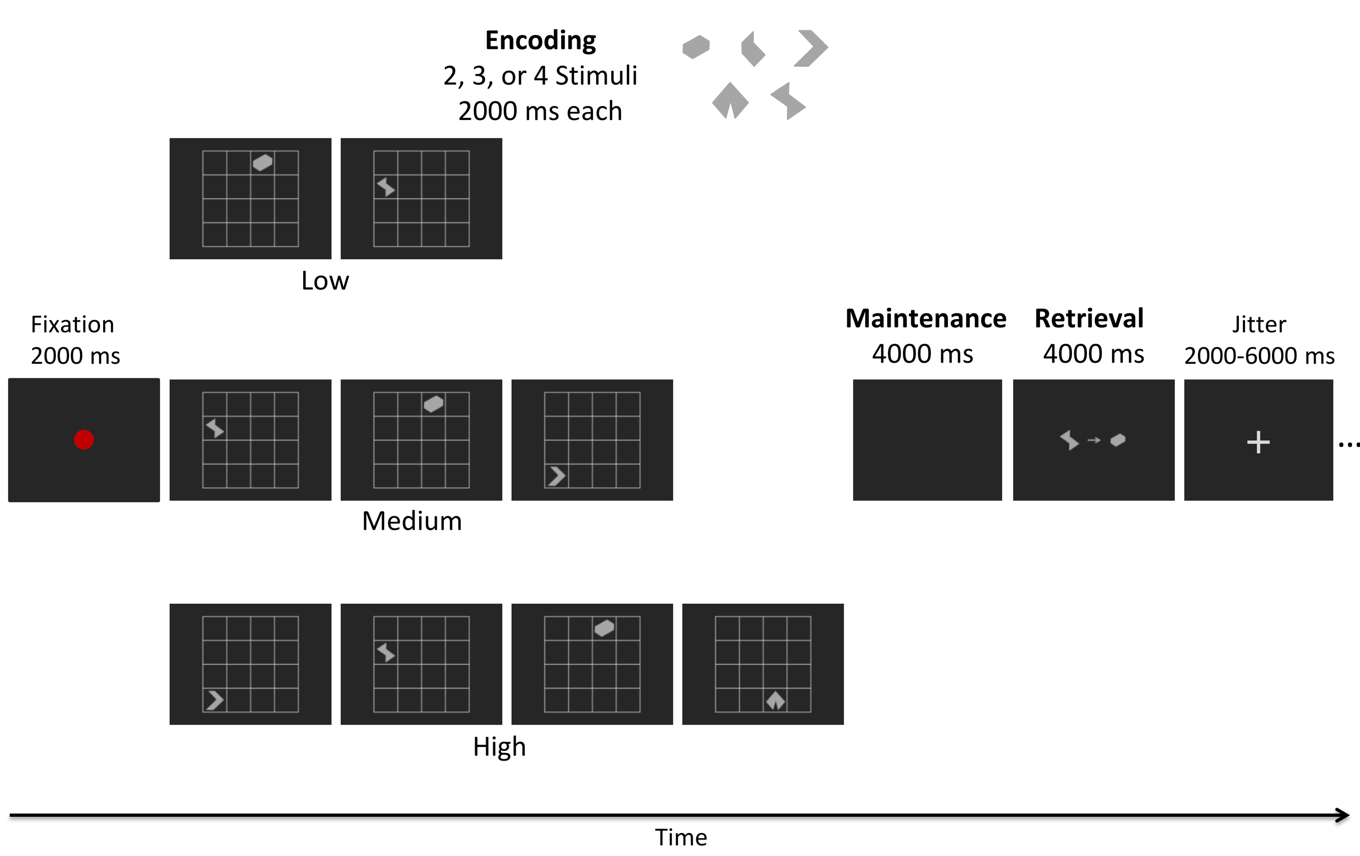
Working memory is a crucial ability for online manipulation of information to guide goal-directed behavior. There is evidence that the working memory capacity and behavioral performance appears to be declined with age; however, increased fronto-parietal activation with age is typically interpreted as being compensatory (Grady, 2012).

In the present study, we explored age-related differences across three levels of task difficulty (high load, medium load, and low load) of working memory for temporal-order information with event-related functional MRI design. In order to minimize the influence of verbal working memory, five abstract objects from previous study by Parra et al. (Parra et al., 2010) were used. In addition, we manipulated levels of task difficulty by utilizing a variety of numbers of items, different from other studies using lag interval.

METHODS

Participants

Eighteen healthy young adults (8 males; mean age 23.2 years, age range 20-26 years) and 16 healthy older adults (3 males; mean age 62.5 years, age range 60-74 years) participated in this study. They are all right-handed native speaker.



Experimental procedure

Each trial began with a red point for 2 s and followed by an encoding phase. During encoding, different levels of task with set sizes two through four were manipulated. The stimuli consisted of one of five abstract objects and a 4-by-4 square grid. In each trial, two (low load), three (medium load), or four (high load) of five abstract objects were randomly chose and put in one of the sixteen small squares. Participants were instructed to memorize the order of those abstract objects. The encoding phase was followed by 4-second blank as a maintenance phase in which participants were asked to remind the order of the just presented abstract objects. During retrieval, two abstract objects were presented with a right arrow in between which indicated the present order of those two objects. Participants were instructed to indicate whether the temporal order is correct by pressing one of two buttons by index or middle finger of right hand once the probe was presented. Trials were separated by a jittered interval of 2, 4, or 6 s. There were total 3 sessions, each consisting of 21, 7 trials for each level.

Imaging Protocol and Data Analysis

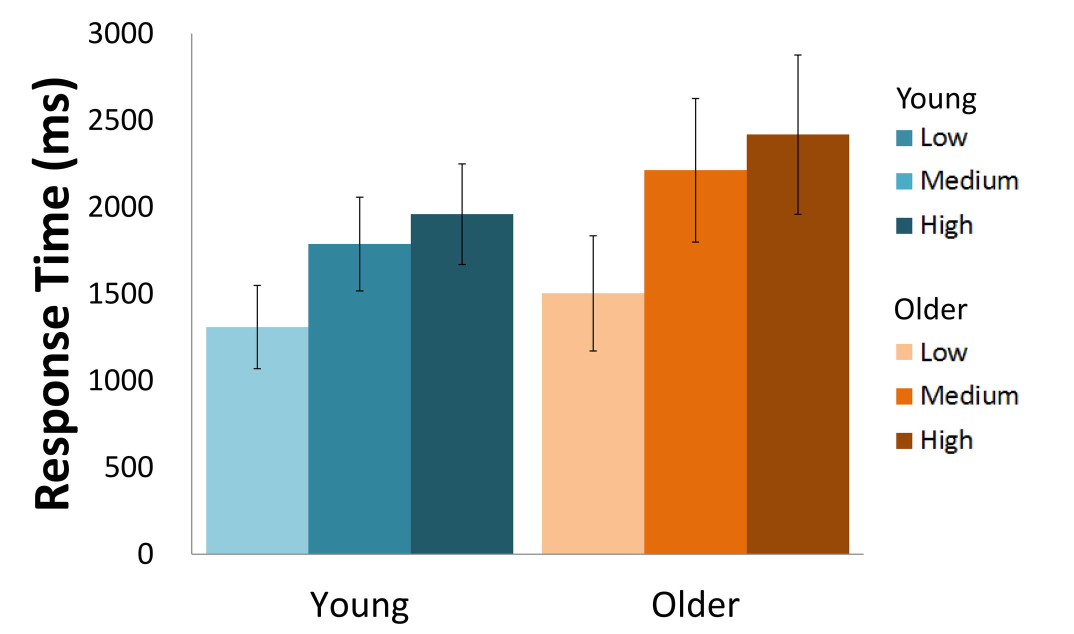
A 3T MRI scanner equipped with a high-resolution 12-channel head array coil (Magnetom Trio, Siemens, Erlangen, German) was used to acquire functional magnetic resonance images. Functional images were acquired using a gradient-echo EPI sequence with following parameters: TR = 2000 ms, TE = 27 ms, FOV = 220 mm, 33 axial interleaved slices.

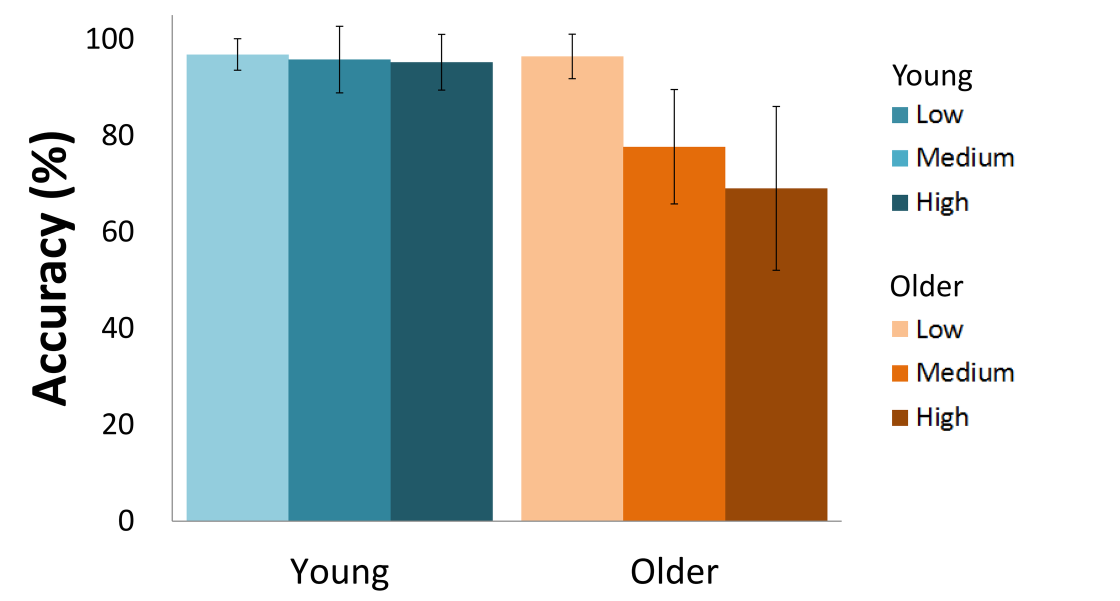
Functional images were pre-processed and analyzed using SPM8. Images were slice-time corrected, realigned, spatially normalized, smoothed with 6 mm FWHM. Event-related BOLD response was modeled by convolving with the canonical hemodynamic response function. Significant regions of activation were identified with threshold uncorrected $p < 0.001$ and cluster size>10.

RESULT & DISSCUSSION

Behavioral results

Our behavioral results showed that both the young and older participants responded slower when the memory load increased. Older participants, but not young participants, showed less accuracy in the high-load conditions.

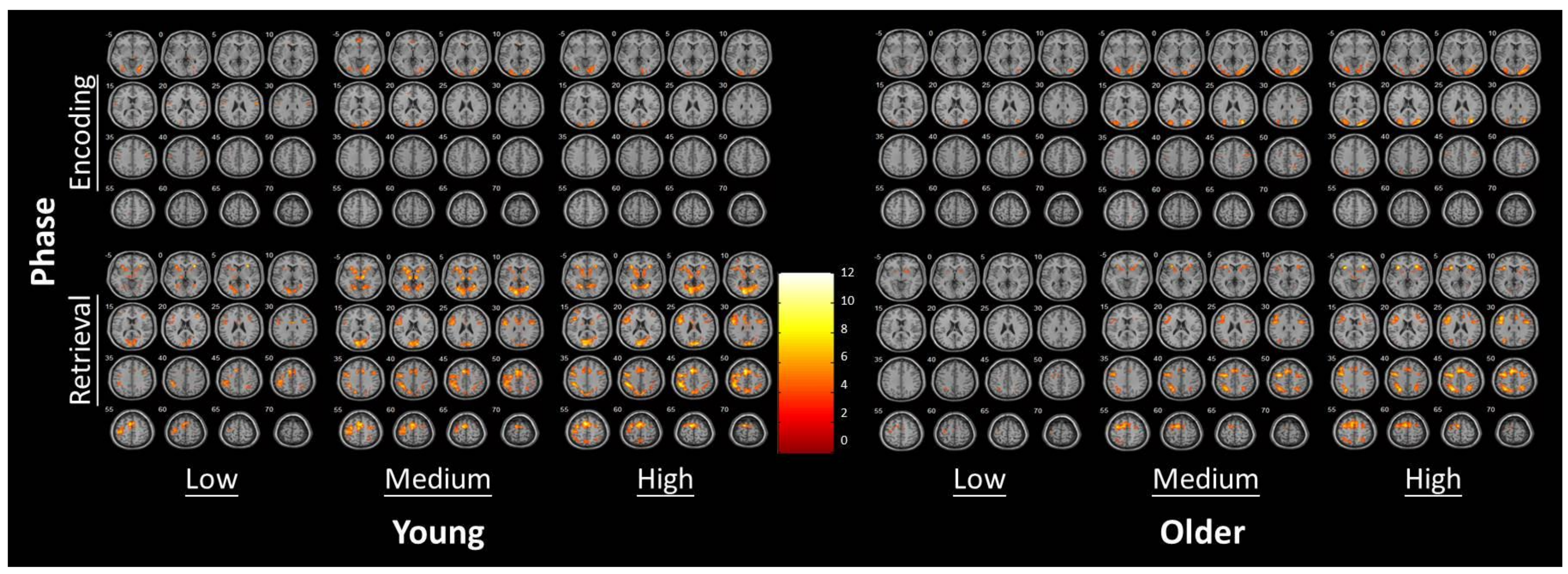




fMRI results

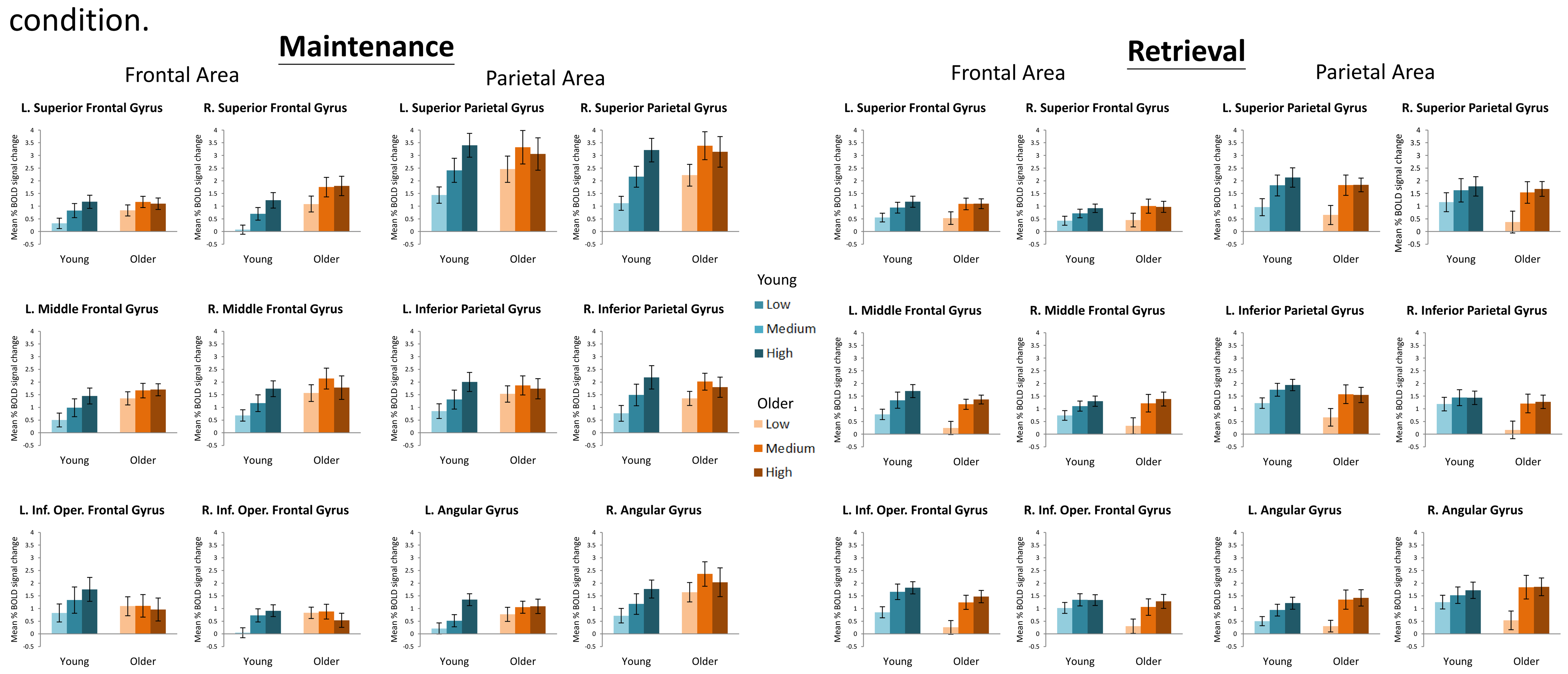
Whole brain analysis

The whole brain analysis of the functional neuroimaging revealed a distributed pattern of fronto-parietal activation for working memory associated with order information across two groups, including dorsolateral prefrontal cortex, middle frontal gyrus, and bilateral posterior parietal regions. However, young participants showed left-lateralized fronto-parietal activation, whereas older participants elicited bilateral activation.



ROI analysis

The ROI analysis showed age-related differences in neural recruitment in response to load effects. Young participants revealed increased parietal activation with increasing task demands, while older group revealed increased parietal activation at the low-load condition and decreased parietal activation at the high-load condition.



CONLUSION

These findings suggest that posterior parietal areas may modulate working memory capacity for order information and provide additional evidence for hemispheric asymmetry reduction in older adults.

REFERENCES

Grady C (2012) Nat Rev Neurosci 13:491-505. Parra MA, Abrahams S, Fabi K, Logie R, Luzzi S, Della Sala S (2009) Brain 132:1057-1066.

ACKNOWLEDGEMENT

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