# Neural basis of the impact of multitasking on working memory performance in older adults

University of California San Francisco

Michael T Rubens, Wesley C Clapp and Adam Gazzaley

Depts. of Neurology, Physiology and Psychiatry - University of California, San Francisco


## Introduction

1) External interference negatively impacts working memory (WM) whether it is completely irrelevant (i.e., distractions), or a component of a concurrent, secondary task (i.e., interruptions, or multitasking)[1,2,3].

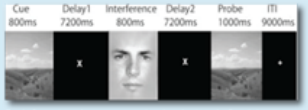
2) We recently showed that interruption negatively impacts the WM performance of healthy older adults to a greater degree than younger adults[4].

3) Our group recently found that the degree to which interruptors are processed correlates with reduced WM performance[4,5]. However, using electroencephalography (EEG) we did not find evidence to suggest that older adults process interrupting stimuli more so than younger adults[5].

4) This suggests that a unique mechanism underlies the negative impact of interruption on WM performance in aging.

## Methods

The paradigm used was the same as performed by younger adults in a recent study[4].




Each functional scan comprised only 1 task. Participants were instructed before each scan which task they would be performing. Each condition comprised 2 scans.

For each trial, participants first saw a cue image which they were told to remember. After a brief delay an interfering stimulus was presented that either required a decision (IS) or was entirely irrelevant (DS). The interference was followed by a second delay, and finally a probe period where participants were shown a test image and had to decide whether or not it matched the image they saw at the beginning of the trial (cue). 32 trials per task.

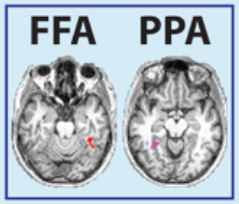
- 20 younger participants (24.6 ± 7 years old, 13 males).
- 20 older participants (69.1 ± 7.2 years old, 7 males).
- After initial screening, older participants were screened with 11 neuropsychological tests to ensure intact executive and memory function.
- All fMRI data were collected on a Siemens 3T Trio Magnetom (2s TR, 33 oblique axial slices with 1.78×1.78×3.5 mm voxels, 25ms TE, 250mm² FoV).
- An independent localizer task was used to identify face-sensitive and scene-sensitive visual association cortices, the fusiform face area (FFA) and parahippocampal place area (PPA) respectively.
- fMRI analyses of functional connectivity employed the bivariate beta-series correlation approach[6] using FFA and PPA ROIs as seed regions.
- The functional connectivity analysis followed the method used in the previous study with younger subjects[4]. This analysis focused on an area in the Middle Frontal Gyrus (MFG) that was defined at the group level by contrasting all memory tasks (IS,DS & NI) against PV.

### Conditions (tasks):

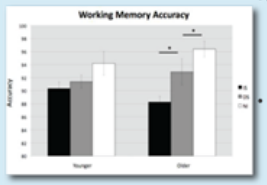
**Interrupting Stimulus (IS):** During the interference period, subjects were instructed to respond to the interfering stimulus if the face was that of a man over 40 years of age.

**Distracting Stimulus (DS):** During the interference period, subjects were instructed that the interfering stimulus was entirely irrelevant.

The experiment also included two other conditions. No Interference (NI), which replaced the interference task stage with a slightly longer delay, and Passively View (PV), which removed any memory elements to control for purely bottom-up visual activity.




## Behavioral Results

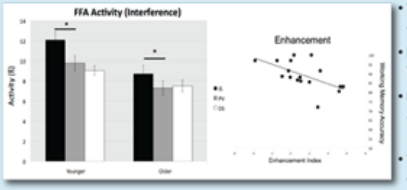



- Comparing accuracy and RT between age groups:
  - The impact of distraction on WM performance did not differ between age cohorts.
  - Older subjects performed significantly worse than younger subjects during interruption (IS)
- Importantly, indices between conditions (NI-IS, NI-DS) were significantly different between age groups. This means that, behaviorally, both distraction and interruption had a greater impact on older adults' WM performance compared to no interference.

## Neural Hypotheses and Results

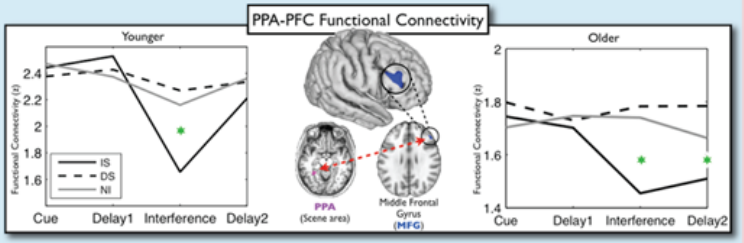
We posited three hypotheses for the neural basis of the aging interruption effect, which were systematically evaluated in the current fMRI study:

### *Hypothesis 1:* Older adults direct more attention toward the interruption.



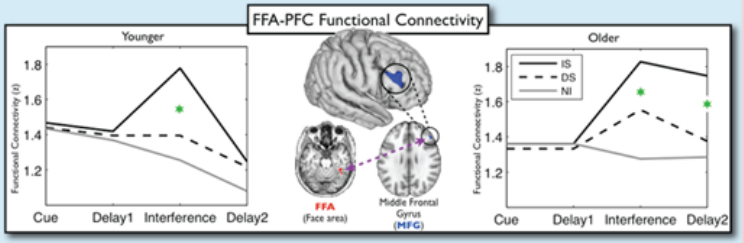

- Younger adults suppress FFA activity when viewing the distractor in DS (compared to PV). Older adults do not.
- Increased activity in response to interference predicts a WM performance decline, replicating EEG results.
- In light of this, the FFA activity seen here for DS provides an explanation for the impact of distraction on WM performance in older adults.
- Yet, age groups do not differ in IS FFA activity, so this does not help explain the impact of interruption on WM.

### *Hypothesis 2:* Older adults fail to reactivate the functional connection of the WM maintenance network following interruption.




- In Young subjects (left panel), interruption causes a large drop in PPA-MFG functional connectivity, but they are able to restore the connection following interference (in Delay 2).
- Older subjects (right panel) also experience a loss of PPA-MFG functional connectivity during interruption, but they are unable to reestablish the connection in Delay 2.
  - This represents the inability of older adults to reactivate the representation of the encoded stimulus.

### *Hypothesis 3:* Older adults continue to process interruptors even after they are no longer present or relevant.




- The interrupting face stimulus captures attention, engaging FFA-MFG connectivity. Young adults (left panel) are able to quickly release the FFA-MFG connectivity in Delay 2.
- Older adults, however, are unable to disengage from the interruption (i.e., persistent FFA-MFG connectivity) in the second delay.

## Conclusions

- Multitasking (i.e., interruption) is associated with a disproportionate drop in working memory performance in older adults, compared to younger adults, replicating previous results.
- Neural data suggest that this aging effect is not mediated by an increase in attention directed toward interrupting stimuli.
- Whole-brain functional connectivity data suggest that older adults have a diminished ability to reactivate internal representations of the stored memoranda following interruption.
- Similarly, older adults appear to have difficulties disengaging from interrupting stimuli. This may be an underlying mechanism of the inhibition deficit of deletion in aging noted by Hasher et al (1999).
- **Multitasking leads to a more significant working memory disruption in older adults due to an inability to dynamically switch between functional neural network connections.**

## References

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Special thanks to: Jasdeep Sabharwal, Chips T Lee, Ted Zanto, Jesse Rissman, Timothy Verstynen & Ezequiel Morsella.
This work was supported by the National Institute of Health, Grant 5R01AG030395 (AG).

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