The Dynamics of Frontal Top-Down Control Networks and their Role in Cognitive Aging

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Introduction

Top-down, or goal-directed, control of attention can be thought of as the conjunction of two processes: enhancement - or attending to task-relevant stimuli - and suppression - or ignoring of task-irrelevant stimuli. When there are competing demands on the attentional networks, failure to suppress will result in a behavioral penalty. This issue has particular relevance to older adults who have a demonstrated deficit in neural suppression of behaviorally relevant stimuli that is correlated with age-related declines in cognitive performance (Gazzaley, 2005).

Here we present an aging fMRI study where there are simultaneous demands on the attentional networks that allows us to parse out regions of the Prefrontal Cortex (PFC) that are associated with suppression and enhancement of the Visual-Association Cortex (VAC). Our approach has yielded two significant findings:

1) There are separate and dissociable PFC-VAC networks associated with suppression and enhancement in both younger and older adults

2) That the suppression network is significantly enlarged in older adults and that this may represent a compensatory mechanism for reduced cognitive and neural resources.

Methods

Experimental Trials: Trial 1: Each trial consisted of two sequentially presented conditions of the same duration with the number of trials correct for each condition presented in randomized order. After a brief delay (800 msec) a visual stimulus was presented for 1000 milliseconds, and participants were instructed to respond to the stimuli if it was shown in one of the previous two images. Subjects were trained on the central location throughout and to respond as quickly and accurately as possible.

Conditions: Each experiment consisted of two randomly interleaved blocks of four trials (Tasks 1 and 2). In addition, a 4-back localizer task consisted of alternating blocks of tasks of faces and scenes from the localizer task described above and correlated trial-by-trial variability of the parameter estimates in the posterior ROIs across all other voxels as described elsewhere (Zarahn, 2003). For all imaging acquisitions, all images were acquired on a Siemens 3-T Trio. fMRI images were concatenated with a 2 s gap, and 18 slices (laminar thickness) for a total voxel size of 1.750 x 1.750 x 3.40 mm. In addition to the 4-back and localizer task, a cognitive elicitation task, and motion and heart rate correction, each condition pair was repeated three times. ROI Results

FIGURE 4 left PPA activity in younger and older adults. We see three levels of activity depending on task instructions (same stimuli). Note that both younger and older participants show significant enhancement while older participants do NOT show suppression. These results are consistent with previous publications demonstrating a selective suppression deficit in older adults (Gazzaley, 2005)

Neural Behavioral Correlation

Changes in Working Memory Performance: SM - SMO...correlated with...

Changes in Functional Connectivity: SM - SMO...

Model of Cognitive Aging

Changes in working memory performance and functional connectivity during task conditions in which older adults show significant impairment in normal aging. Nat Neurosci (2000) vol. 8 pp. 1298-300

Conclusions/Future Directions

1) There is evidence for separate frontal suppression and enhancement networks in young adults during a selective attention task with simultaneous demands

2) These networks are altered in older adults where frontal enhancement networks contain regions (such as the ACC) associated with suppression in young adults

3) The magnitude of reallocation of frontal resources is correlated with increases in performance on a distractor-present task in older adults

4) This reallocation of resources may be a compensatory mechanism for age-related cognitive decline

References


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reprints are available at:
http://gazzaley.ucsf.edu/meeting-presentations.html