Working Memory Filtering and Individual Differences in Second Language Aptitude

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Introduction

Individuals differ in their ability to acquire a second language (L2). Although not included in classical models (Carrillo, 1995), working memory (WM) has received increasing attention as a construct that relates to L2 aptitude (Rayko & Friedman, 1998).

Prior work linking WM to L2 aptitude has taken a capacity view (Just & Carpenter, 1992); however, recent research suggests that a precursor to capacity is the ability to “control access” to WM by blocking task-irrelevant information (McNab & Klingberg, 2008; Vogel, McCullough, & Machizawa, 2002).

In the present study we adopt a “control access” view of WM, and investigate whether L2 aptitude is reliant on the ability to flexibly filter out task-irrelevant stimuli.

Hypothesis 1: Selective WM filtering underlies L2 aptitude, individuals who are better at filtering irrelevant information from WM (”good” filters) are better L2 learners than “poor” filters.

Hypothesis 2: The ability to filter out task-irrelevant information is supported by fronto-striatal circuit functioning.

Methods

An fMRI study of WM filtering was conducted using a verbal WM task (Figure 1, modeled after McNab & Klingberg, 2008). Following the MRI, participants completed:

- Eight 30-minute French language learning sessions using a virtual immersion software (Prat et al., 2018)
- A French post-test containing vocabulary and grammar questions

Participants

- Monolingual English speakers (N = 34, 22 female)
- Ages 18-34 (M = 20.47)
- Right-handed

Imaging Analyses

Images were corrected for slice acquisition timing, motion-corrected, normalized, co-registered, and smoothed to decrease spatial noise. Statistical analyses were performed using the general linear model in SPM8. Contrasts of interest were correlated with post-test scores.

Results

Behavioral Task Accuracy:

<table>
<thead>
<tr>
<th></th>
<th>Filter</th>
<th>No-Filter</th>
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<tbody>
<tr>
<td>3 Items</td>
<td>M = 0.92 (SD = 0.11)</td>
<td>M = 0.86 (SD = 0.09)</td>
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<tr>
<td>5 Items</td>
<td>M = 0.88 (SD = 0.12)</td>
<td>M = 0.85 (SD = 0.12)</td>
</tr>
<tr>
<td>Total</td>
<td>M = 0.90 (SD = 0.09)</td>
<td>M = 0.88 (SD = 0.10)</td>
</tr>
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Influence Phase fMRI Activity:

• Less preparatory activity in bilateral medial temporal regions predicted higher vocabulary post-test performance (Figure 2).

• More preparatory activity in bilateral parietal and right fronto-temporal regions predicted higher grammar post-test performance (Figure 2).

Task fMRI Activity:

• Task Filtering A: Better filtering, as indexed by smaller differences in activation between Filter 5 and No-Filter 3 conditions in left DLPFC, predicted higher vocabulary post-test performance (Figure 3).

• Task Filtering B: Better filtering, as indexed by larger differences in activation between No-Filter 5 and Filter 5 in left DLPFC, left parietal lobe, and ACC, predicted higher vocabulary post-test performance. Larger activation differences in ACC also predicted higher grammar post-test performance (Figure 3).

Conclusions

These results demonstrate that neural activity associated both with preparing to filter (proactive control) and with successful filtering in a verbal WM task predict L2 acquisition. These results support Hypothesis 2 as better filters were also better language learners. Hypothesis 2 was partially supported, as better filtering was indexed by activation differences in the prefrontal cortex; however, differences in striatal activation did not relate to language learning. Future work using Dynamic Causal Modeling may illuminate whether striatal activation drives prefrontal activation (e.g., O’Reilly & Frank, 2006).

Taken together, these results provide evidence that “controlling access” to WM predicts L2 acquisition, and may therefore be an important component of L2 aptitude.

References


