Research on second language (L2) acquisition has identified a common network of regions recruited during L2 processing: the language control network. Activity in this network is thought to be inversely correlated with proficiency, such that less proficient learners show more activity compared to more proficient learners. Yet, these regions are also frequently implicated in studies of proficient and even simultaneous bilinguals.

New multivariate techniques offer an opportunity to evaluate more fine-grained distinctions between the neural correlates of L2 processing in low and high proficiency learners.

Materials & Procedure

Outside the Scanner

- Language History Questionnaire
- Handedness and Color Vision Test
- AX-Continuous Performance Test
- Spanish Category Verbal Fluency
- Post-Experiment Questionnaire (PEQ)

Inside the Scanner

Semantic Decision Task
- Judge if a word is larger or smaller than a shoebox
- Blocks of English, Spanish, Homographs
- All words chosen from Spanish 002 textbook

Go-Nogo Task

Stop-signal Task
- Initial stop-signal delay: 200ms
- Adjusted via staircase procedure by 64ms

MRI Preprocessing & Analysis

- Connectivity analysis using GIMME
  - ROIs extracted using Marsbar
  - Multivariate preprocessing and analysis conducted with the Decoding Toolbox in conjunction with SPM12
  - Trial types (English, Homograph, Spanish) differentiated at individual level prior to decoding

Behavioral Results

<table>
<thead>
<tr>
<th></th>
<th>Low Proficiency</th>
<th>High Proficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>Spanish Self-Rating (SSR)</td>
<td>4.36 (.78)</td>
<td>5.13 (.67)</td>
</tr>
<tr>
<td>Spanish Verbal Fluency (DVF)</td>
<td>21.89 (6.75)</td>
<td>33.4 (7.56)</td>
</tr>
<tr>
<td>SDT Spanish Accuracy</td>
<td>0.64 (0.12)</td>
<td>0.81 (0.1)</td>
</tr>
<tr>
<td>SDT Spanish RT**</td>
<td>1121 (122)</td>
<td>994 (88)</td>
</tr>
<tr>
<td>PEQ Accuracy*</td>
<td>44 (4.9)</td>
<td>47.5 (1.5)</td>
</tr>
</tbody>
</table>

* p<.05, ** p<.01, *** p<.001

Methods

Participants

Low Proficiency Learners:
- Recruited from 002-100 level Spanish
- N=18 (14 female)
- Mean age=19.2 years

High Proficiency Learners:
- Recruited from 300+ level Spanish
- N=15 (12 females)
- Mean age=20.6 years

The support vector machine classifier was able to distinguish High proficiency learners from Low proficiency learners based on activity in the language control network.

High Proficiency
- Ordered fronto-basal circuit
- Feedback from motor system
- Feeds forward to attentional system

Low Proficiency
- Motor-centric network
- Reflects poorer task performance

Conclusions

The combination of multivariate and connectivity analyses of L2 BOLD data show that the effects of proficiency are not limited to the overall activation level in the language control network.

As learners increase in proficiency, the multi-voxel activation patterns within those regions also change to become more consistent, even across learners. This co-occurs with more ordered connectivity patterns within the fronto-basal control network.

Furthermore, the fact that the classifier identified regions in the language control network provides novel support for the importance of the language control network as identified by Abutalebi and Green.

References


Contact Information

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