Exploring the Relationship between Language Ability and Executive Functioning

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Background

Executive Functioning:
- A set of higher-order cognitive processes responsible for regulating and coordinating mental activities essential for goal-oriented behavior and adaptive problem-solving
- A uniquely human cognitive ability, a key component of which is inhibition of inhibitory control (Shin et al., 2015)

“THE BILINGUAL ADVANTAGE”:
- The idea that bilinguals may have cognitive benefits including improved executive functioning
- The validity of the theory is controversial due to various confounding trends
  - Supported by the Adaptive Control Framework theory proposed by Green and Abutalebi in 2011
  - However, performance on tasks that measure executive functioning vary between bilinguals due to factors such as code switching frequency, phonological and orthographic similarity of L2 to English, L2 proficiency (inter vs. between language interference), cortical thickness (Summy & Haxby, n.d., p.), (Kroll & Chastellé, 2019).

The Stroop Task:
- In “Studies of Interference in Serial Verbal Reactions” by Stroop in 1935 established that an automatic process, such as reading, can interfere with one’s ability to accurately complete an alternative goal
- The “Interference Effect”, now more widely known as the “Stroop Effect” occurs when there is conflict between the word’s meaning and the color that is presented in, causing the participant to take longer interpreting the color due to interference they may experience
- This phenomenon demonstrates the challenges in inhibiting automatic processes and highlights complexities of cognitive control for both monolinguals and multilinguals.
- The design enabled us to measure participant’s ability to inhibit an automatic response (reading) and maintain cognitive flexibility when confronted with conflicting stimuli.

Hypothesis:

My hypothesis for this project is that bilingual or multilingual individuals will show a smaller Stroop Effect, higher accuracy, and faster reaction time relative to their monolingual counterparts, which would theoretically correspond with enhanced executive functioning abilities. The underlying hypothesis is that exposure with code (language) switching strengthens the existing neural circuitry that also works to facilitate executive functioning.

Subjects

<table>
<thead>
<tr>
<th>Monolingual Subjects</th>
<th>Multilingual Subjects</th>
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</thead>
<tbody>
<tr>
<td>Sample Size</td>
<td>10</td>
</tr>
<tr>
<td>Gender Distribution (M:F)</td>
<td>1:4</td>
</tr>
<tr>
<td>Age Mean (S.D., Range)</td>
<td>22.5 (5.8), 15-30</td>
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</tbody>
</table>

Table 1. Subject demographics data and summary statistics.

Methods

- All subjects participated in the Stroop Task from the same computer
- Controls for keyboard and display differences
- The Stroop Task was administered on PyToolKit (software for running cognitive-psychology experiments)
- The Stroop Effect or the “Interference Effect” was calculated using the equation: (INT-RT)<(CON-RT) = Stroop Data

- Appropriate demographic data was provided:
  - Numerical data: gender, age, L1, L2
  - Categorical data: race, year in school, group

- Data was analyzed using R Studio
- Linear regression models
- Spearman’s correlation, due to abnormal data distribution

Results

- The matrix shows a positive correlation between accuracy and English exposure. The Stroop Task was administered in English, and the data suggests that those with more exposure to English performed better.
- Small positive correlation between Stroop Effect and English exposure:
- Higher English exposure was more common amongst the monolingual subject group, potentially implying an inferior performance (larger Stroop Effect) is related to language.
- Group had a small negative correlation with accuracy, potentially implying more cognitive interference which led to reduced accuracy.
- This could be between or interlanguage interference, depending on variables such as language proficiency and code switching frequency.

Conclusions

- Due to small sample size and other limiting factors, there were no statistically significant conclusions drawn
- English exposure showed a small positive correlation with both accuracy and Stroop Effect
- The Stroop Task was administered in English, and that is a component unable to be isolated from accuracy. However, in the future if the test administered to the participants L2, perhaps we could yield different results.

- A larger Stroop Effect from monolingual (less linguistically exposed) individuals could imply more difficulty inhibiting automatic processing due to loss of cognitive flexibility.
- Generally, bilingual subjects reported less frequent average exposure to English.

- The Adaptive Control Framework (Green and Abutalebi, 2013) assumes which cognitive mechanisms are engaged is dependent on environmental demands. These factors may affect the neural network in response to language experience (Kroll & Chastellé, 2015).

- Negative correlation between group and accuracy could potentially imply more cognitive interference from subject’s L2.

- The monolingual subject group had an older mean age, and therefore have experienced more education, which potentially influenced accuracy.

- Bilingual people are known to experience more between-language interference when their proficiency is lower, whereas highly proficient bilinguals experience more interlanguage interference (Shin et al., 2018).

- The phonological and orthographic similarity between the color names in subjects’ L1 and L2 could also influence accuracy, reaction time, and Stroop Effect.

- Orthographic similarities between languages e.g. “sw” in English and “sc” in German could decrease in accuracy

- Although the Stroop Task is a written task, studies have implied involvement of unintentional phonological processes, which could potentially influence how the stimuli was interpreted, creating between interference. Eg. “blue” in English and “bl” in German have no orthographic overlap, but the phonology could unintentionally be interpreted during lexical access (Summy & Haxby, n.d., p.).

- The monolingual subject group showed a slower mean reaction time compared to the bilingual group. This aligns with my original hypothesis that bilingual individuals more adeptly blocked cross stimuli interference to perform better on the Stroop Task.

- This was potentially reflected in the data but since error bars completely overlap, a large sample size is required.

Future directions:

- This study should be redeveloped in the future, with an increased sample size and compensation for participants
- Undergraduate researchers are USAC have plans to expand on my original research in the Fall of 2023 under the guidance of Dr. Barakat

- With more time, I would examine this through a phonology lens, examining how languages more similar in English overlap with the Stroop Task stimuli
- This would provide information for understanding the effect of anticipatory processing on a multi-lateral environment.

- This could potentially include implementing a bilingual Stroop Task in order to further subdivide the multilingual subject group.

References


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bridge.usc.edu/bugs

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