Understanding Relationship Between Multilingualism and Executive Functions

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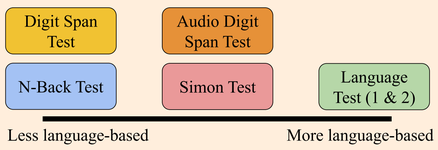
Background and Introduction

Executive Function (EF) refers to a variety of broad cognitive skills (such as working memory) that are important for day-to-day human functionality. Our project focuses on the relationship between EF and language experience, emphasizing the difference between monolingual and multilingual individuals.

Subjects in our dataset are evaluated on five different EF tests which vary in their connection to language. Subjects' linguistic backgrounds are captured via self-evaluations of language proficiency and information related to language acquisition.

Fig. 1 EF Tests' Connection to Language



The goal of our project is to illuminate:

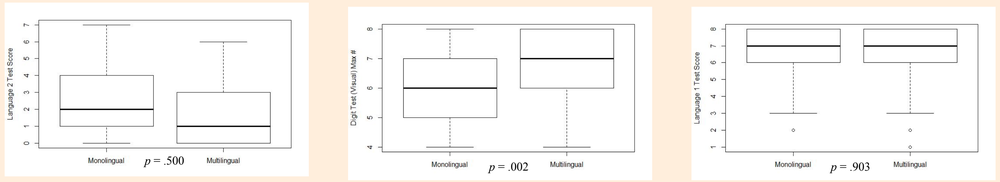
(1) How the effect of 'lingualism on EF test scores relates to the test's connection to language.

(2) Which aspects of linguistic experience are especially related to variation in EF abilities.

Data Exploration

The data for this project are provided by Dr. Erik Thiessen and Maureen Hilton from CMU's department of Psychology. Preliminary exploration of the data reveals differences in how 'lingualism affects EF based on the test examined, as well as differences between different versions of the same test.

Fig. 2 Some EF Test Scores, by 'lingualism

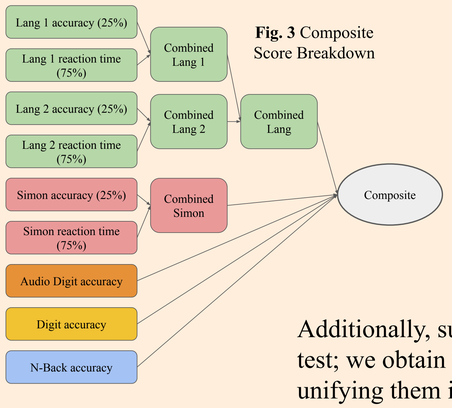


We pre-process our data in two ways to account for this:

(1) To help establish a baseline relationship between 'lingualism and EF, we create a composite EF score that combines the scores of the five EF tests into a single value.

(2) To better reflect each participant's overall language experience, we develop a total language proficiency score.

Fig. 3 Composite Score Breakdown

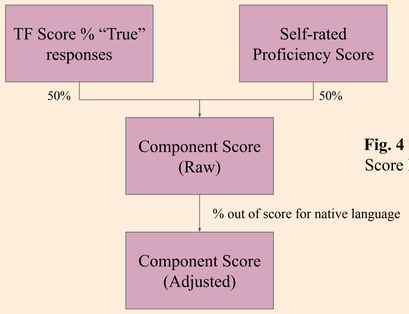


Our composite score is made by standardizing the measured score(s) of each test and then averaging the corresponding probability values.

The Lang and Simon tests each have two scores associated with them; for these, we take a weighted average of probabilities to generate a combined test score that is used for determining the composite score. We give more weight to the reaction time score because we find that they correlate more with EF.

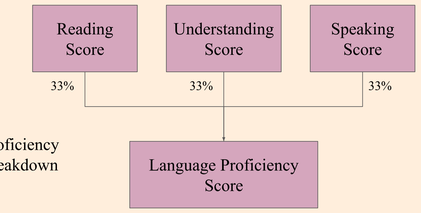
Additionally, subjects were given one of two versions of the Lang test; we obtain probability values for these separately before unifying them into a single combined Lang value.

Data Exploration (Cont.)



For each of reading, understanding, and speaking, we calculate a component score based on language experience.

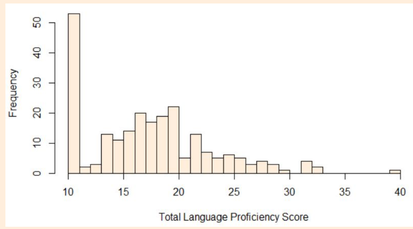
Fig. 4 Proficiency Score Breakdown



For each language a participant speaks, we calculate a language proficiency score based on the component scores. The total proficiency score is the sum of the language proficiency scores of all languages that a participant speaks.

For each of reading, understanding, and speaking, the total component proficiency score is the sum of the component proficiency scores of all languages that a participant speaks.

Fig. 5 Distribution of Total Language Proficiency Scores



Method and Results

We run OLS regressions of each EF test score against each component of language proficiency score, controlling for gender.

Table 1. Adjusted *r* and *p*-Values of Correlations Between EF Test Scores (Columns) and Language Proficiency Scores (Rows)

	Composite	Language Test (lang1)	Language Test (lang2)	Simon Test	Audio Digit Span Test	Digit Span Test	N-Back Test
Total	.021 (*p*=.026*)	.049 (*p*=.016*)	.052 (*p*=.094.)	.018 (*p*=.150)	.021 (*p*=.783)	.056 (*p*=.002**)	.001 (*p*=.763)
Reading	.027 (*p*=.017*)	.068 (*p*=.007**)	.039 (*p*=.172)	.013 (*p*=.233)	.021 (*p*=.727)	.091 (*p*<.001***)	.002 (*p*=.631)
Understanding	.014 (*p*=.046*)	.021 (*p*=.050.)	.049 (*p*=.110)	.021 (*p*=.116)	.021 (*p*=.734)	.029 (*p*=.014*)	.001 (*p*=.975)
Speaking	.017 (*p*=.037*)	.049 (*p*=.016*)	.063 (*p*=.060.)	.017 (*p*=.158)	.022 (*p*=.918)	.044 (*p*=.004**)	.001 (*p*=.705)

*Note: . p < .1, * p < .05, ** p < .01, *** p < .001*

We find significant, weak correlations between: (1) composite EF score and all components of language proficiency; (2) language test score with language 1 and all components of language proficiency except understanding (which is marginally significant); (3) digit test score and all components of language proficiency.

The strongest correlations are between reading proficiency and scores in digit span test and language test with language 1. The weakest correlations are between n-back test scores and understanding and speaking proficiency.

For tests with a reaction time component, we find that the reaction time has a stronger correlation with linguistic proficiency than the accuracy component.

Conclusion

- Linguistic proficiency is significantly correlated with general executive functioning (via our aggregate composite score).
- Linguistic proficiency is more strongly correlated with performance in the language test with language 1 and the digit test, as evidenced by greater adjusted *r* for their correlations.
- Executive functioning is more strongly correlated with reading proficiency compared to speaking and understanding proficiency, as evidenced by greater adjusted *r* for their correlations.