Investigating the Role of General Cognitive and Language-Specific Factors in Natural Language and Programming Language Learning

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Introduction

Language aptitude predicts programming ability[1].

The Modern Language Aptitude Test (MLAT) is based on Carroll's four-factor model of language aptitude[2]:

- Inductive learning ability
- Rote memory
- Grammatical sensitivity
- Phonemic coding ability

If there is shared variance between individual differences in learning a natural language and learning a programming language, how much of it is explained by general cognitive factors vs. more specific language-learning factors?

Hypothesis 1: The overlap is primarily explained by general cognitive factors related to learning.

Hypothesis 2: The overlap is primarily explained by the language-like structure and the content of the information to be learned.

Hypothesis 3: The overlap is explained by a combination of general learning and language aptitude factors.

To explore these hypotheses, the present study measures:

- Analogous learning outcomes in French and Python in the same individuals
- How aspects of language aptitude, ranging from general cognitive factors to those specific to language learning, might explain shared variance between learning outcomes in French and Python.

Method

Participants: Twenty native English speakers aged 18-35

Language training:

French: Sixteen 30-minute immersive training sessions over 8 weeks (OLCTS)[3]

Python: Ten 45-minute learning sessions (Codecademy's Learn Python 2 course)[1]

Measures obtained prior to training:

General cognitive factors:
- Fluid Intelligence (Raven's Advanced Progressive Matrices)
- Working Memory (Operation Span)

Language-specific factors:
- Number Learning (MLAT I)
- Phonetic Script (MLAT II)
- Spelling Cues (MLAT III)
- Words in Sentences (MLAT IV)
- Paired Associates (MLAT V)

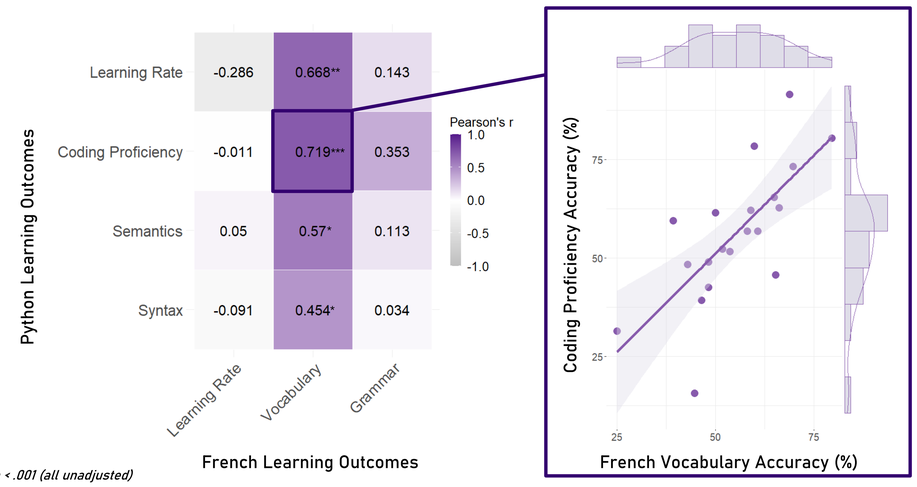
Measures obtained after training:

French learning outcomes:
- Learning Rate (Slope)
- Vocabulary (multiple-choice and free translation)
- Grammar (multiple-choice)

Python learning outcomes:
- Learning Rate (Slope)
- Coding Proficiency (production coding task)
- Semantics (multiple-choice)
- Syntax (multiple-choice)

Results

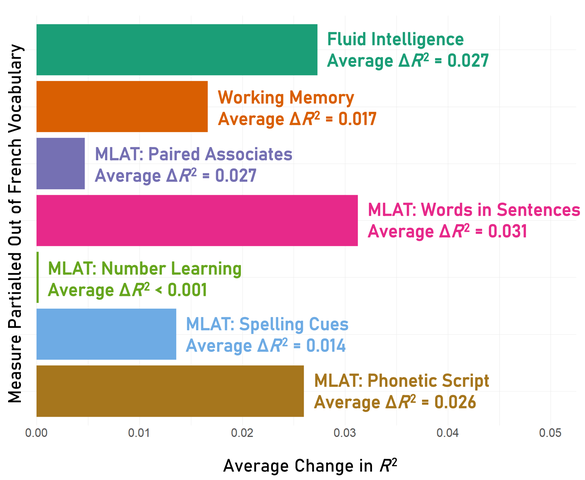
Bivariate Correlations Between French Learning Outcomes and Python Learning Outcomes



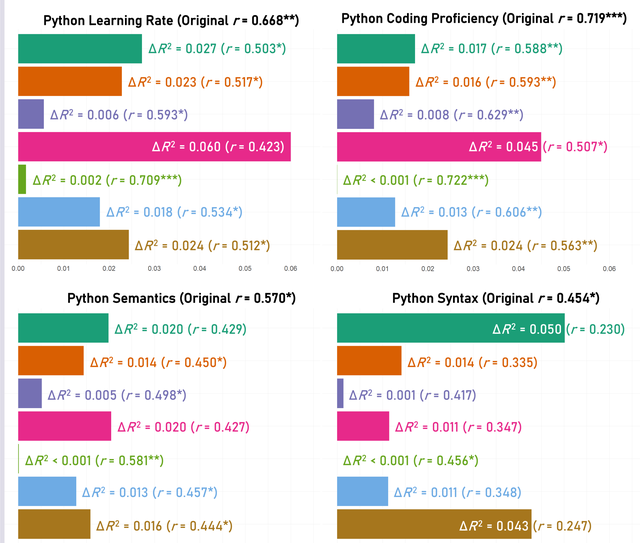
*p < .05, **p < .01, ***p < .001 (all unadjusted)

Partial Correlations Between French Vocabulary and Python Learning Outcomes

Average Change in R^2 Across Partial Correlations Between French Vocabulary and All Python Learning Outcomes



Change in Pearson's r Across Partial Correlations Between French Vocabulary and Individual Python Learning Outcomes



Discussion

Both general cognitive factors and those related more specifically to language-learning explained co-variance in learning outcomes.

None of the single factors explored explained the majority of the variance. Most of the outcomes remained significantly correlated even when the strongest covariates were factored out.

French Vocabulary was the strongest predictor of all Python learning outcomes. This may indicate that declarative/associative learning processes drive some of the shared variance in Python and language learning.

However:

- Words in Sentences (MLAT IV) always explained more variance than Paired Associates (MLAT V)
- This may suggest that knowledge about English specifically underpins the relation between learning French and Python.

Future directions:

- Factor analysis of current data: Do French learning outcomes contribute even when all of the cognitive factors are controlled for?
- How does English proficiency (L1 vs L2 learners) relate to Python learning and language aptitude assessment?

References

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