The Effect of Second Language Proficiency on Inhibitory Control: An Ex-Gaussian Analysis

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Introduction

Background:

- Mixed findings of a bilingual advantage on resistance to distractor interference (e.g., a congruency effect) may be due to analysis issues, e.g.,
  1. Performance measures are limited to participants' RT means. Individual differences in inhibition are most apparent in the tail of the RT distribution (Roelofs, Piai, & Garrido Rodriguez, 2011) rather than the mean.
  2. Bilingualism is often treated as a categorical variable, but degree of bilingualism is actually a continuous variable (Luk & Bialystok, 2013). By only comparing bilinguals and monolinguals, it is unknown whether the phenomenon of better performance by bilinguals is a categorical one or not.
- If bilingualism enhances executive control, then within bilinguals, higher proficiency should be associated with better performance.
- Using ex-Gaussian analysis, Calabria et al. (2011) found that bilinguals had smaller central tendencies (μ) and tails (τ) than monolinguals across all trials (congruent and incongruent), but a group difference in the congruency effect was only observed in τ.
- We explored the relation between **degree of L2 proficiency** (as a continuous variable) and performance on a task measuring **resistance to distractor interference**. We ran an **ex-Gaussian analysis**, which characterizes various parameters of a skewed distribution.

Hypothesis:

We expected to find an effect of L2 proficiency on performance for incongruent (but not congruent) trials and only in τ (not μ), indicating that higher proficiency is associated with small congruency costs in the tail of the distribution.

Methods

Participants:

- 42 Brazilian Portuguese-English bilinguals
- Ages 18-37 (m = 26.1); 30 females
- Residence in U.S.: 2 weeks – 18 mos. (m = 4.4 mos.)

English Proficiency Measures

	Min	Max	Mean
Self-rating (mean) *6 language skills, 1-7*	1.83	5.67	4.44
Can-Do Questionnaire (mean) *Functional communication, 1-5*	1.72	4.61	3.57
Vocabulary test *Picture naming, 140 items*	21.4%	75.4%	50.1%
Michigan Test of English Language Proficiency *Auditory comprehension, 45 items, accuracy*	33.3%	97.8%	73.9%

Proficiency composite = mean of standardized scores on all 4 measures

Measure of Resistance to Distractor Interference

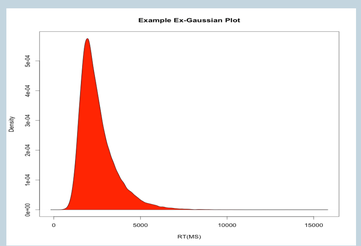
- Variable Position Flanker Task: Target appears in 2nd, 3rd, or 4th positions
- More difficult than classic Flanker Task, which shows ceiling effects

Congruent: < < < < < Incongruent: < < < > <

Results

We estimated ex-Gaussian parameters for each participant and used these as outcome variables in a mixed effects model.

Step 1: μ, σ and τ parameters were estimated for each condition within each participant using the *RETimes* package in *R*.

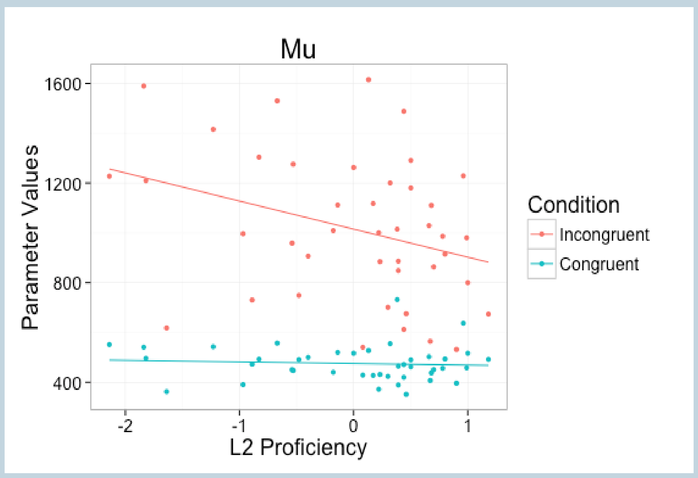


μ – The mean of the Gaussian component (the peak)

τ – The exponential component (thickness of tail and skewness)

Step 2: A linear mixed effects model with the μ and τ estimates as outcomes and parameter (μ or τ), condition (congruent or incongruent), L2 proficiency and their interactions as predictor variables.

- Parameters and conditions nested within participants
- Categorical variables sum-coded for main effects
- Inferences based on Satterthwhaite approximated degrees of freedom and bootstrapped confidence intervals
- Because of mild heteroscedasticity, robust linear mixed effect models were also fit (using the *robustlmm* package); inferences did not change.



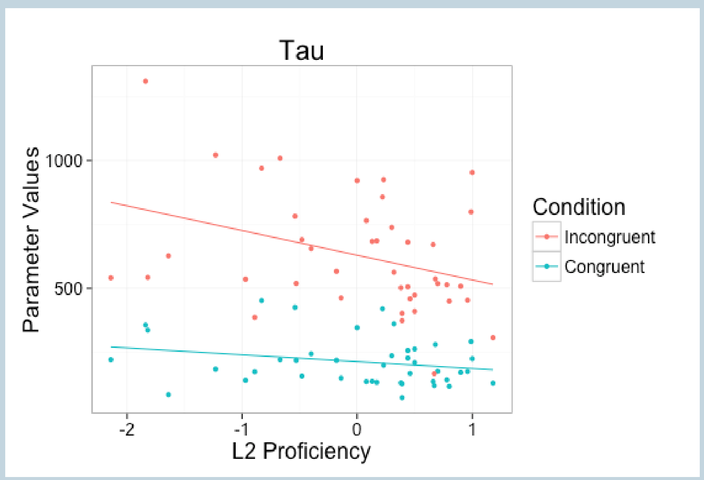


Table 1: Mixed Effects Model Estimates (Confidence Intervals)

	Full Model	Congruent Only	Incongruent Only
Main Effects:			
Intercept	745*** (703 : 784)	476*** (451 : 496)	1015*** (925 : 1096)
Condition *(congruent, incongruent)*	270*** (232 : 310)		
Parameter *(μ, τ)*	-324*** (-373 : -275)	-262*** (-296 : -230)	-386*** (-469 : -309)
Proficiency *(continuous)*	-60* (-109 : -11)	-6 (-35 : 28)	-113* (-201 : -11)
Interactions:			
Parameter X Condition	-62* (-119 : -11)		
Parameter X Proficiency	-2 (-67 : 54)	-20 (-66 : 20)	16 (-91 : 124)
Condition X Proficiency	-53* (-94 : -11)		
Condition X Proficiency X Parameter	18 (-38 : 81)		

Summary

- Main effect of proficiency on global RT, driven by incongruent trials. The effect was not moderated by parameter type.
- Interaction between proficiency and condition showing effect of proficiency on incongruent but not congruent trials.

Conclusions

- Within bilinguals, L2 proficiency is associated with better resistance to distractor interference, suggesting that this bilingual advantage is a continuous rather than a categorical phenomenon.
- The causal directionality is not known: The results imply either that L2 acquisition leads to increased executive control or that higher executive control contributes to L2 proficiency.
- A proficiency advantage was observed on congruency costs in both μ and τ (instead of just τ). This might be because continuous variables are more sensitive to small effects than categorical variables.
- This study demonstrates a bilingual advantage in resistance to distractor interference using a more sensitive measure of bilingualism (proficiency continuum) and a more sensitive measure of task performance (RT distributional analysis).

References & Acknowledgements

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