

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

Proficiency composite = mean of standardized scores on all 4 measures

Measure of Resistance to Distractor Interference

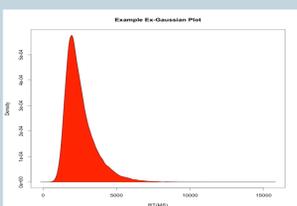
- Variable Position Flanker Task: Target appears in 2nd, 3rd, or 4th positions
- More difficult than classic Flanker Task, which shows ceiling effects

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 Satterthwaite 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.

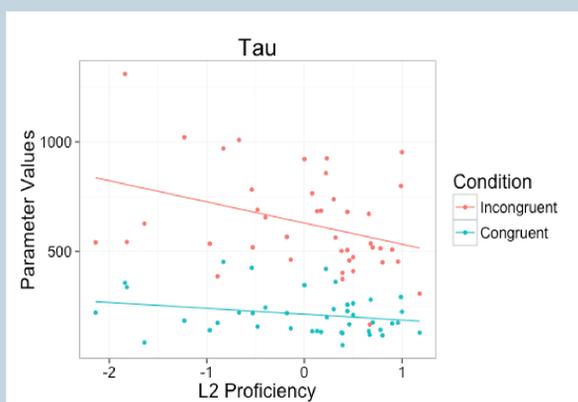
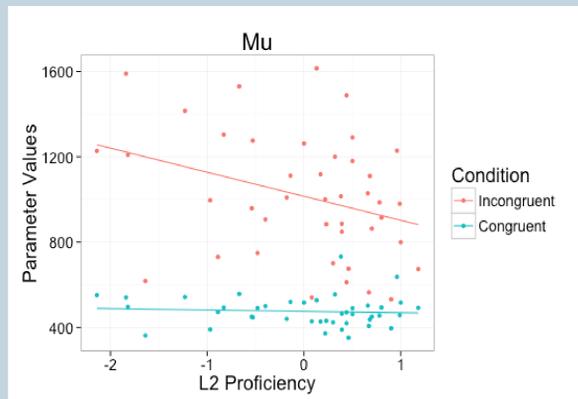


Table 1: Mixed Effects Model Estimates (Confidence Intervals)

	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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