Addressing one research question using multiple methodological approaches

Marc Goodrich

IN OUR GRIT, OUR GLORY™

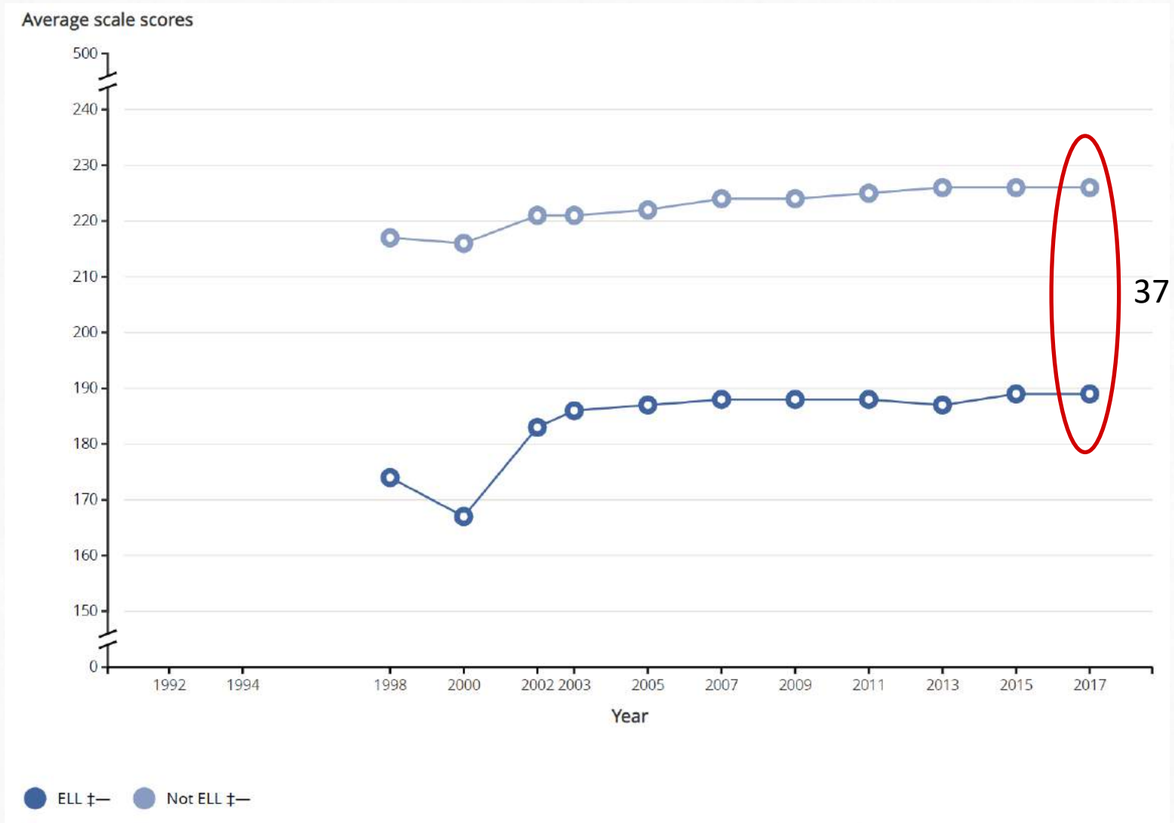
Overview

- Background and theory on dual language learners
- Using regression-based approaches
- Examining scale versus item-level data
- Using factor analytic methods
- Using experimental methods

Background – Dual Language Learners

- Dual language learners (DLLs) have significantly lower academic achievement than do monolingual children across subjects and grades

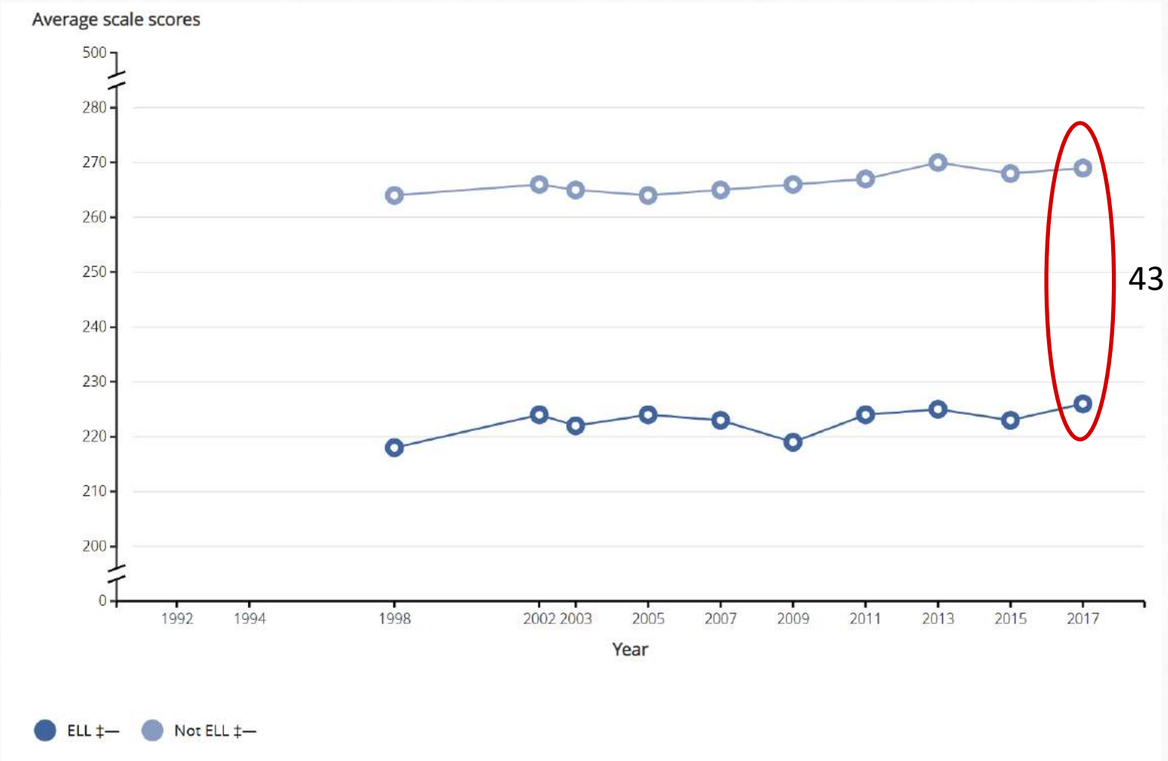
- Reading achievement by ELL status at 4th grade



Background – Dual Language Learners

- Dual language learners (DLLs) have significantly lower academic achievement than do monolingual children across subjects and grades

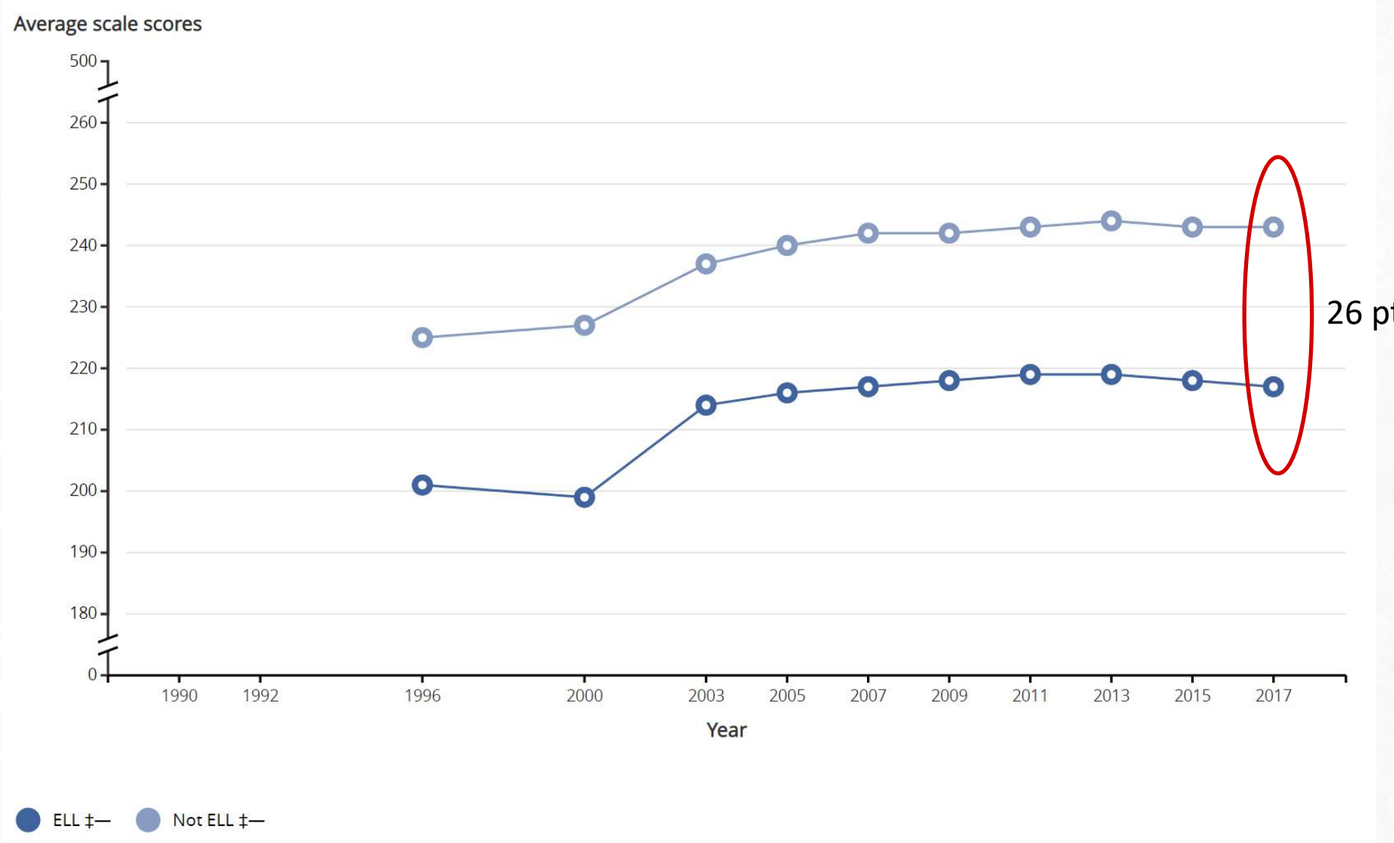
- Reading achievement by ELL status at 8th grade



Background – Dual Language Learners

- Dual language learners (DLLs) have significantly lower academic achievement than do monolingual children across subjects and grades

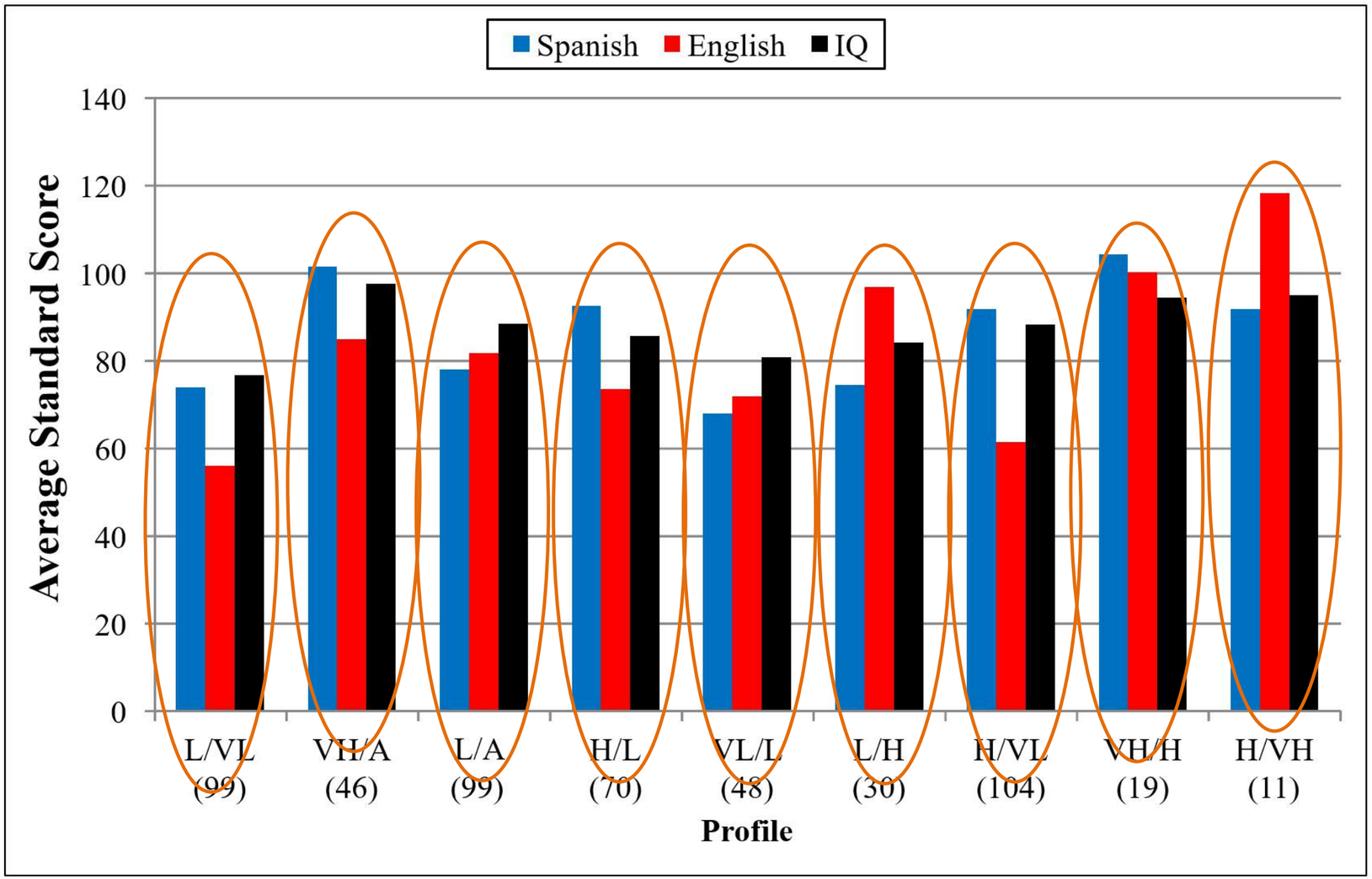
- Math achievement by ELL status at 4th grade



Heterogeneity among DLLs

- Typical conceptualization of English language learners
  - High first language (L1) skills, low second language (L2) skills
- Latent Profile Analysis
  - 554 Spanish-speaking DLL preschoolers
  - Measures of receptive and expressive language skills in Spanish and English
  - Accounting for IQ

Heterogeneity among DLLs



So, what do we do to address the achievement gap?

- Identify instructional approaches that work best for promoting achievement
    - English-only instruction
    - Dual language instruction
        - Transitional
        - Maintenance
- Understand how academic skills develop for DLLs, and if this development is substantively different than it is for monolingual children

Theory of L1 and L2 development

- Developmental Interdependence Hypothesis (Cummins, 1979)
  - “The level of L2 competence which a bilingual child attains is partially a function of the type of competence the child has developed in L1 at the time when intensive exposure to L2 begins.” (p. 233)
  - For children with high L1 competence, “intensive exposure to L2 is likely to result in high L2 competence with no cost to L1 competence.” (p. 233)
  - For children with low L1 competence, “intensive exposure to L2…is likely to impede the continued development of L1. This will, in turn, exert a limiting effect on the development of L2.” (p. 233)

In other words….

- Dual language learners can potentially transfer knowledge and skills developed in L1 to L2, assuming adequate exposure to L2

- Research question: Can DLLs transfer reading-related/early literacy skills from L1 to L2?

    - Word reading
    - Reading comprehension
    - Vocabulary knowledge/oral language
    - Alphabet knowledge/letter-sound correspondence
    - Phonological awareness

Prior Research

- Most studies have simply evaluated zero-order correlations or examined the relations across L1-L2 variables using multiple regression

Journal of Educational Psychology
1993, Vol. 85, No. 3, 453–465

0022-0663/93/$3.00

Cross-Language Transfer of Phonological Awareness

Aydin Y. Durgunoğlu, William E. Nagy, and Barbara J. Hancin-Bhatt

A study investigated the factors influencing the English word identification performance of Spanish-speaking beginning readers. Beginning readers were administered tests of letter naming, Spanish phonological awareness, Spanish and English word recognition, and Spanish and English oral proficiency. Multiple-regression analyses revealed that the readers' performance on English word and pseudoword recognition tests was predicted by the levels of both Spanish phonological awareness and Spanish word recognition, thus indicating cross-language transfer. In contrast, neither English nor Spanish oral proficiency affected word-identification performance. Results suggest a specific way in which first-language learning and experience can aid children in the beginning stages of reading.

Journal of Educational Psychology
2006, Vol. 98, No. 1, 159–169

0022-0663/06/$12.00 DOI: 10.1037/0022-0663.98.1.159

The Intriguing Role of Spanish Language Vocabulary Knowledge in Predicting English Reading Comprehension

C. Patrick Proctor
Harvard Graduate School of Education

Diane August
Center for Applied Linguistics

María S. Carlo
University of Miami

Catherine Snow
Harvard Graduate School of Education

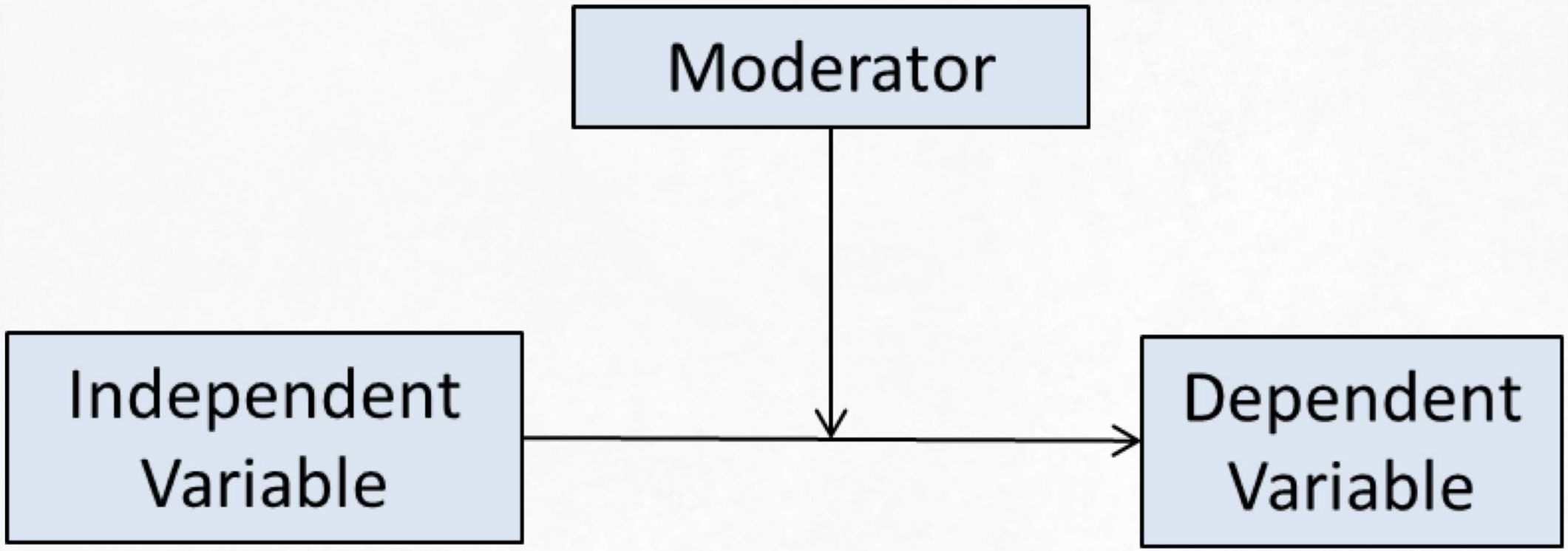
This study explored a holistic model of English reading comprehension among a sample of 135 Spanish–English bilingual Latina and Latino 4th-grade students This model took into account Spanish language reading skills and language of initial literacy instruction. Controlling for language of instruction, English decoding skill, and English oral language proficiency, the authors explored the effects of Spanish language alphabetic knowledge, fluency, vocabulary knowledge, and listening comprehension on English reading comprehension. Results revealed a significant main effect for Spanish vocabulary knowledge and an interaction between Spanish vocabulary and English fluency, such that faster English readers benefited more from Spanish vocabulary knowledge than their less fluent counterparts. This study demonstrates the existence of literary skills transfer from the 1st to the 2nd language, as well as limits on such transfer.

Keywords: bilingualism, vocabulary, cross-linguistic transfer, Spanish language

Meta-Analytic Evidence

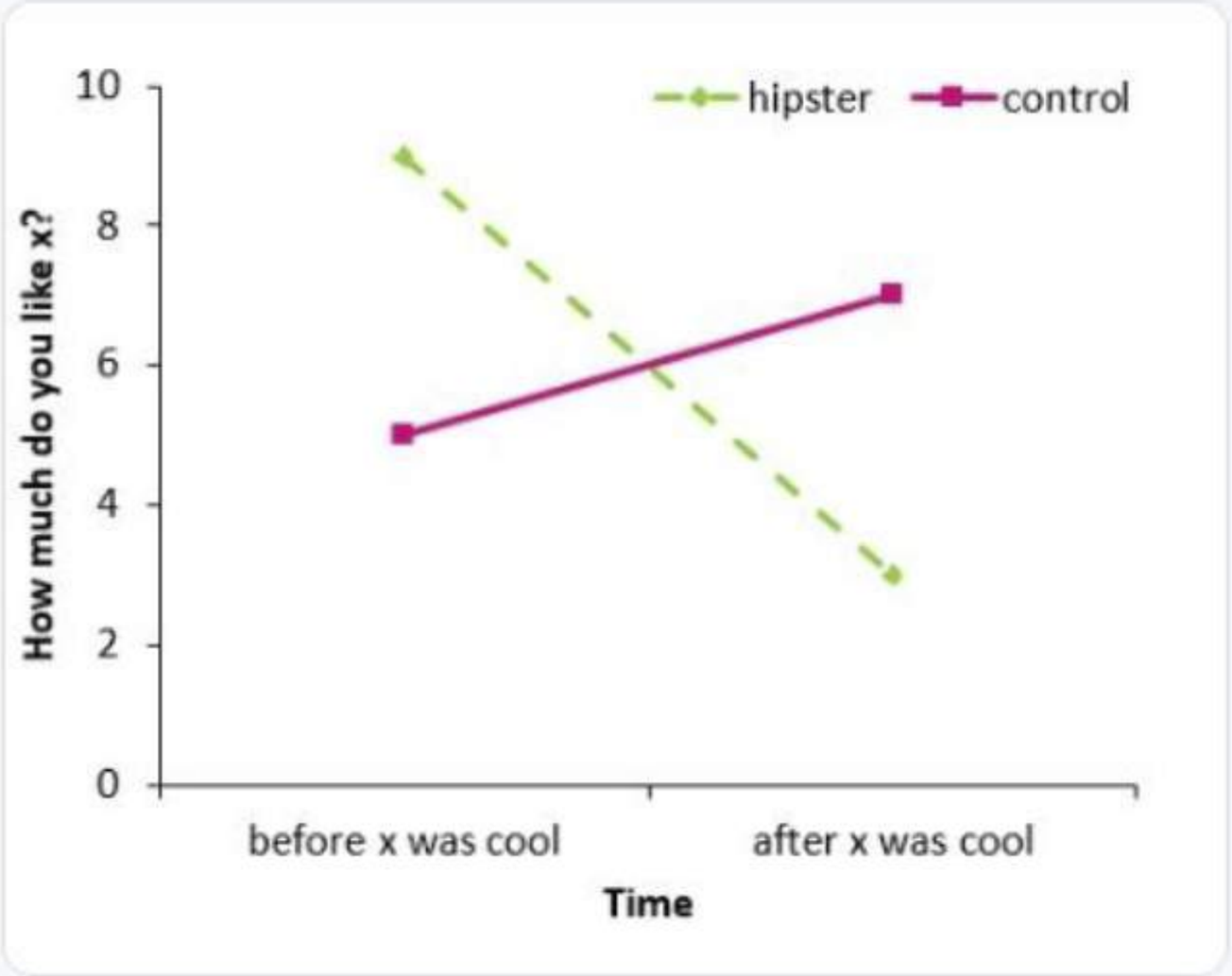
- Melby-Lervåg & Lervåg (2011)
  - L1-L2 word reading, *r* = .54
  - L1 phonological awareness-L2 word reading, *r* = .44
  - L1-L2 phonological awareness, *r* = .66
  - L1 word reading-L2 reading comprehension, *r* = .24
  - L1-L2 oral language, *r* = .16
  - L1 oral language-L2 reading comprehension, *r* = .04

Using Moderation Analysis to Examine Cross-Language Transfer



Dr. Vanessa Loaiza @vmloaiza1 · Oct 25

Oh I'm so grateful to you EJ because I always did feel hokey about this one because it's an ordinal interaction, even if it's funny to explain, so just for you and Loftus (1978) I'll show one of my funny crossover ones 😉



3 13 80

Using Moderation Analysis to Examine Cross-Language Transfer

- Research question
  - Are children's phonological awareness skills correlated across languages?
  - Do the cross-language relations between L1 and L2 phonological awareness differ based on L1 oral language skills?

- Goodrich, Lonigan, and Farver (2014)
  - 466 Spanish-speaking preschoolers
  - Completed measures of Spanish and English phonological awareness and expressive language skills

Using Moderation Analysis to Examine Cross-Language Transfer

- RQ1: Are phonological awareness skills correlated across languages?

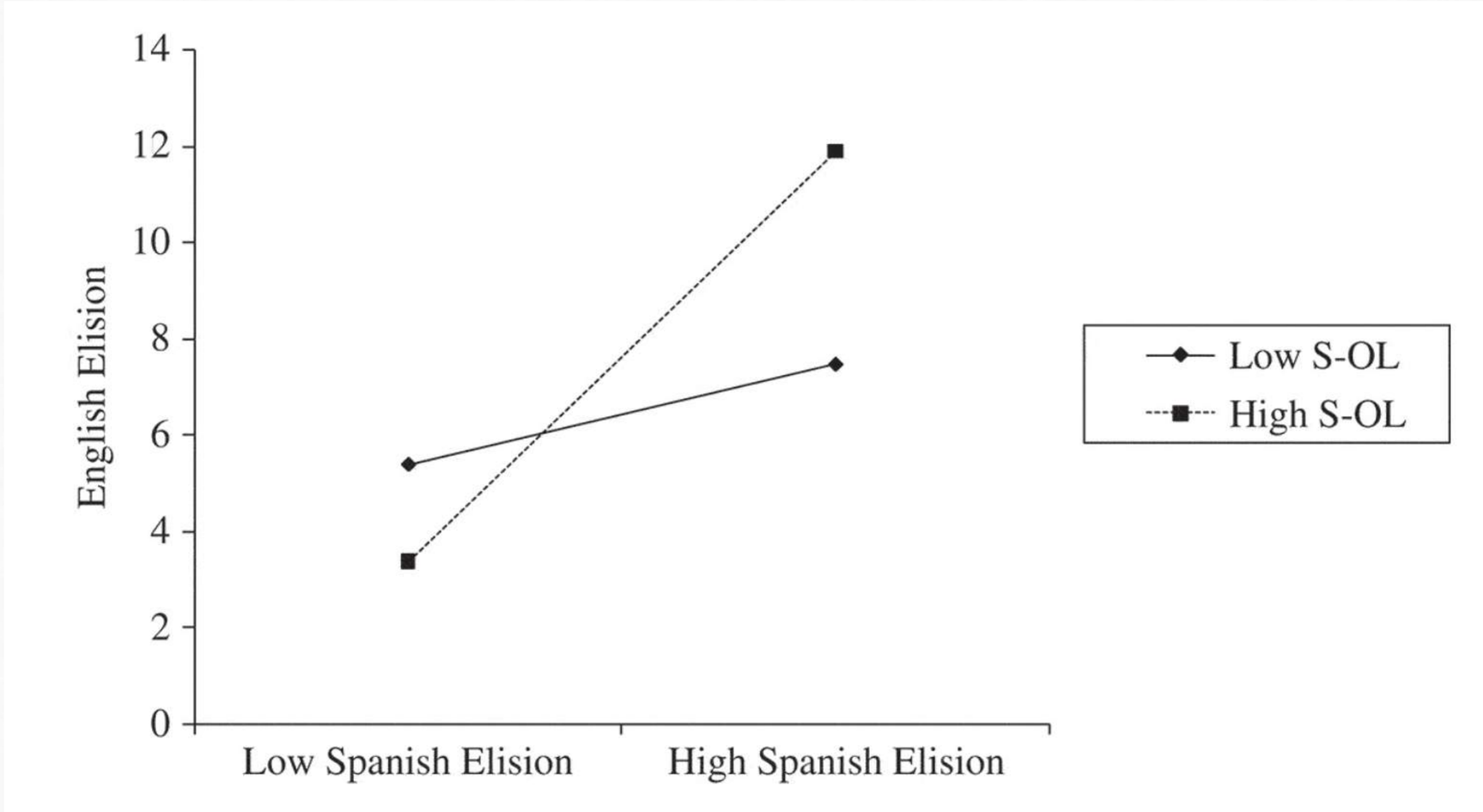
Descriptive Statistics and Zero-Order Correlations for Spanish and English Emergent Literacy Skills

	M (SD)	*Range*	*Spanish Blending*	*English Elision*	*Spanish Elision*	*English Language*	*Spanish Language*
English Blending	12.00 (4.62)	0–21	**.39*****	.48***	**.29*****	.54***	**.20*****
Spanish Blending	11.53 (3.81)	0–18		**.31*****	.29***	**.31*****	.35***
English Elision	6.47 (2.98)	0–18			**.46*****	.47***	**.23*****
Spanish Elision	6.09 (2.59)	0–18				**.24*****	.35***
English Oral Language	77.52 (16.65)	50–122					**.27*****
Spanish Oral Language	93.33 (18.92)	50–141					

Note. $N = 466$. Bold correlations show cross-language correlations.
***$p < .001$.

Using Moderation Analysis to Examine Cross-Language Transfer

- RQ2: Are L1-L2 phonological awareness relations moderated by Spanish language skills?

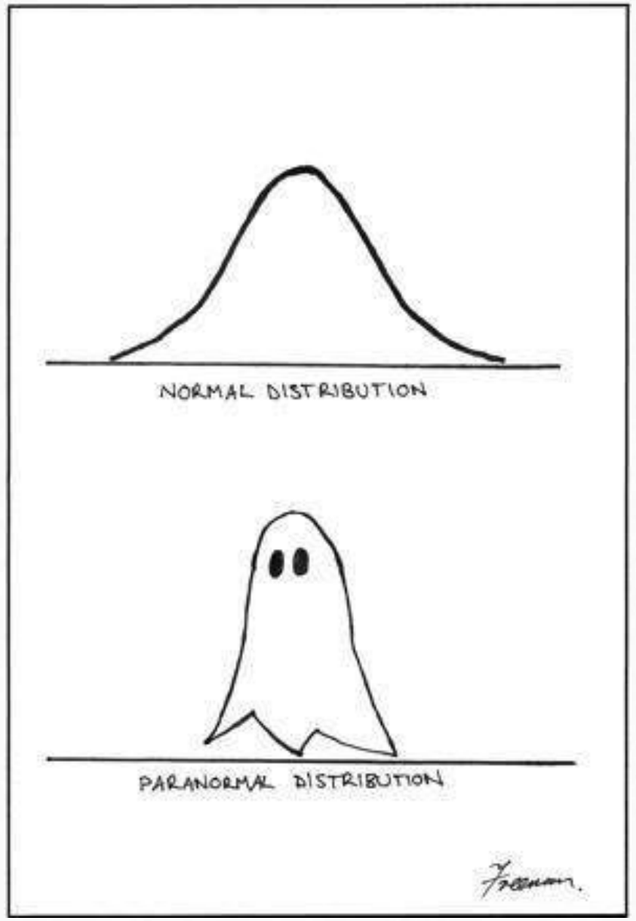


Limitations of Using Concurrent Regression-Based Approaches

- Significant relations between constructs may vary as a function of a third, unmeasured construct
- Open to alternative explanations
  - Observed relations may be due to common language learning environment across L1 and L2
  - Observed relations may be due to underlying language learning capacity or intelligence
- More longitudinal or experimental evidence needed to provide evidence for transfer

Quantile Regression

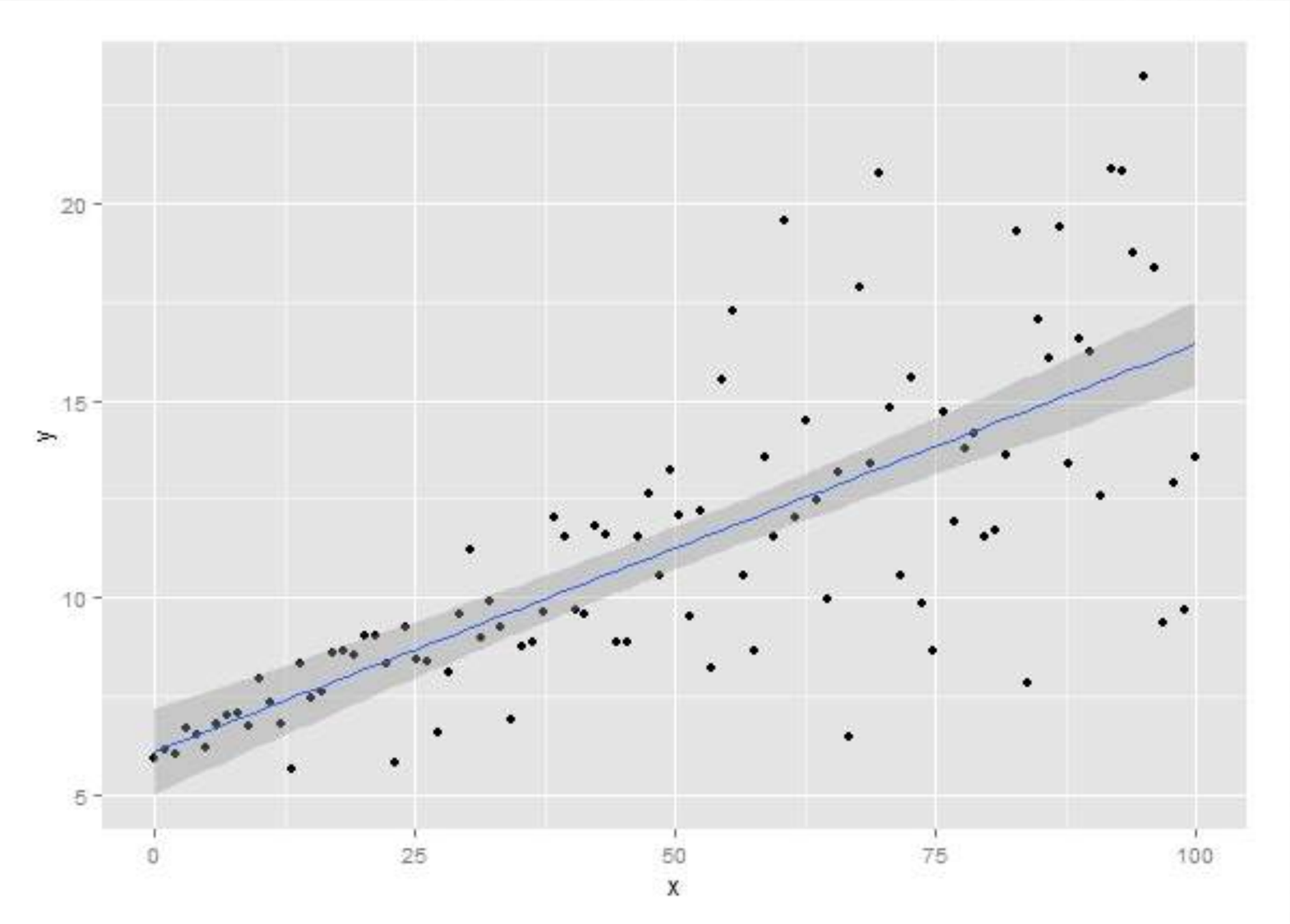
- OLS regression examines the effect of one variable at the mean of the other
  - Assumes constant variance in the outcome
  - Assumes normally distributed residuals



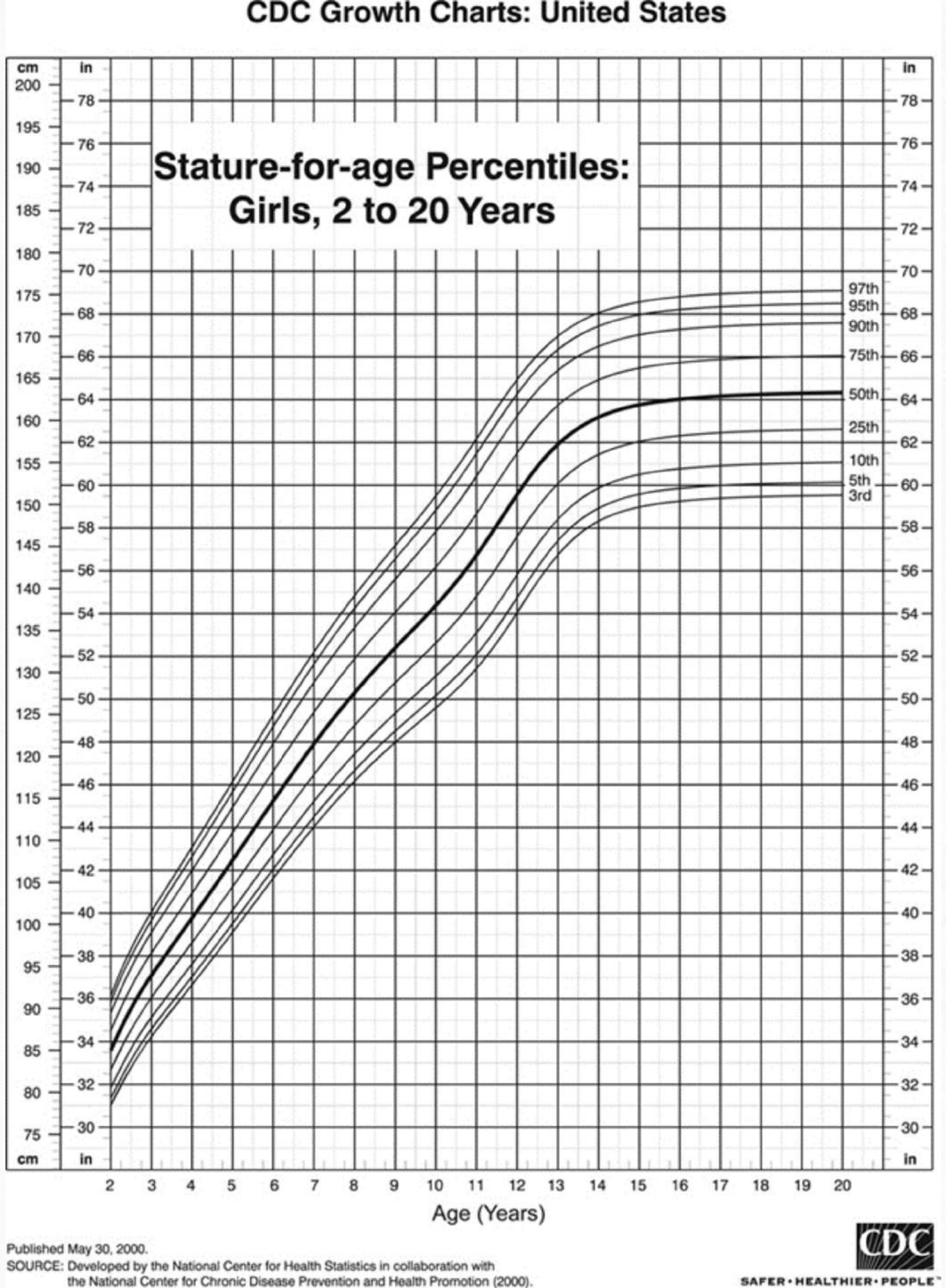
Quantile Regression

- OLS regression examines the effect of one variable at the mean of the other
  - Assumes constant variance in the outcome
  - Assumes normally distributed residuals
- If variance in DV differs across levels of the IV, OLS regression will not describe the data equally well across the distribution of the IV
- Quantile regression gives a slope estimate at multiple points across the distribution of the outcome variable
  - Petscher and Logan (2014)

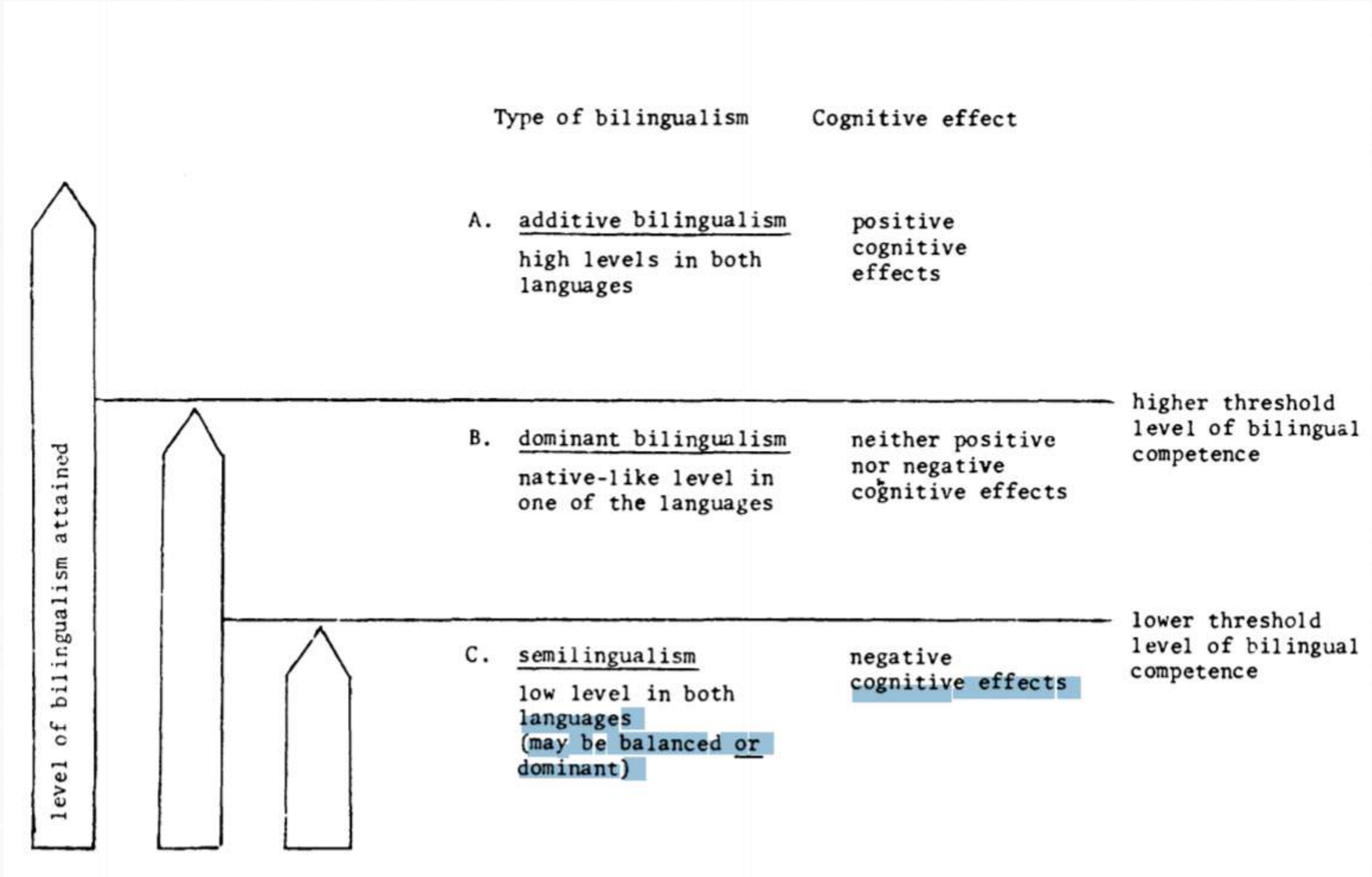
Quantile Regression (Ford, 2015)



Petscher & Logan (2014; p. 862)



Threshold Hypothesis (Cummins, 1979; p. 230)



Threshold Hypothesis

- Cross-language relations are not constant across the continuum of L2 proficiency (Feinauer, Hall-Kenyon, & Everson, 2017)
- Does the correlation between L1 and L2 academic skills differ for children with different levels of L2 skill?
    - Can be addressed using quantile regression, examining the correlation at varying quantiles of L2 ability

Using Quantile Regression to Investigate Cross-Language Transfer

- 944 Spanish-speaking DLL preschoolers
- Completed measures of oral language, phonological awareness, and print knowledge in L1 and L2
- Interpreting quantile regression
    - Standard OLS regression interpretation (b = .5): 1 unit increase in x is associated with a .5 increase in y
    - Alternative interpretation (for standardized coefficients): the coefficient is the difference in y at the mean of x when compared to 1 SD above the mean of x
    - Alternative interpretation can be directly applied to quantile regression with standardized (z-scored) variables

Interpreting Quantile Regression

- Two z-scored variables (x and y)
  - Mean(x) = 0, SD(x) = 1; Mean(y) = 0, SD(y) = 1

- At 75th percentile of y, the estimated slope coefficient is .8, and intercept is 0.1
  - y = .1 + 0.8x

  - At the mean of x: y = .1 + (.8)*(0) = .1
  - At one standard deviation above the mean of x: y = .1 + (.8)*(1) = .9

- The difference in the 75th percentile of y between individuals at the mean and at one standard deviation above the mean of x is 0.8
  - .9 - .1 = .8

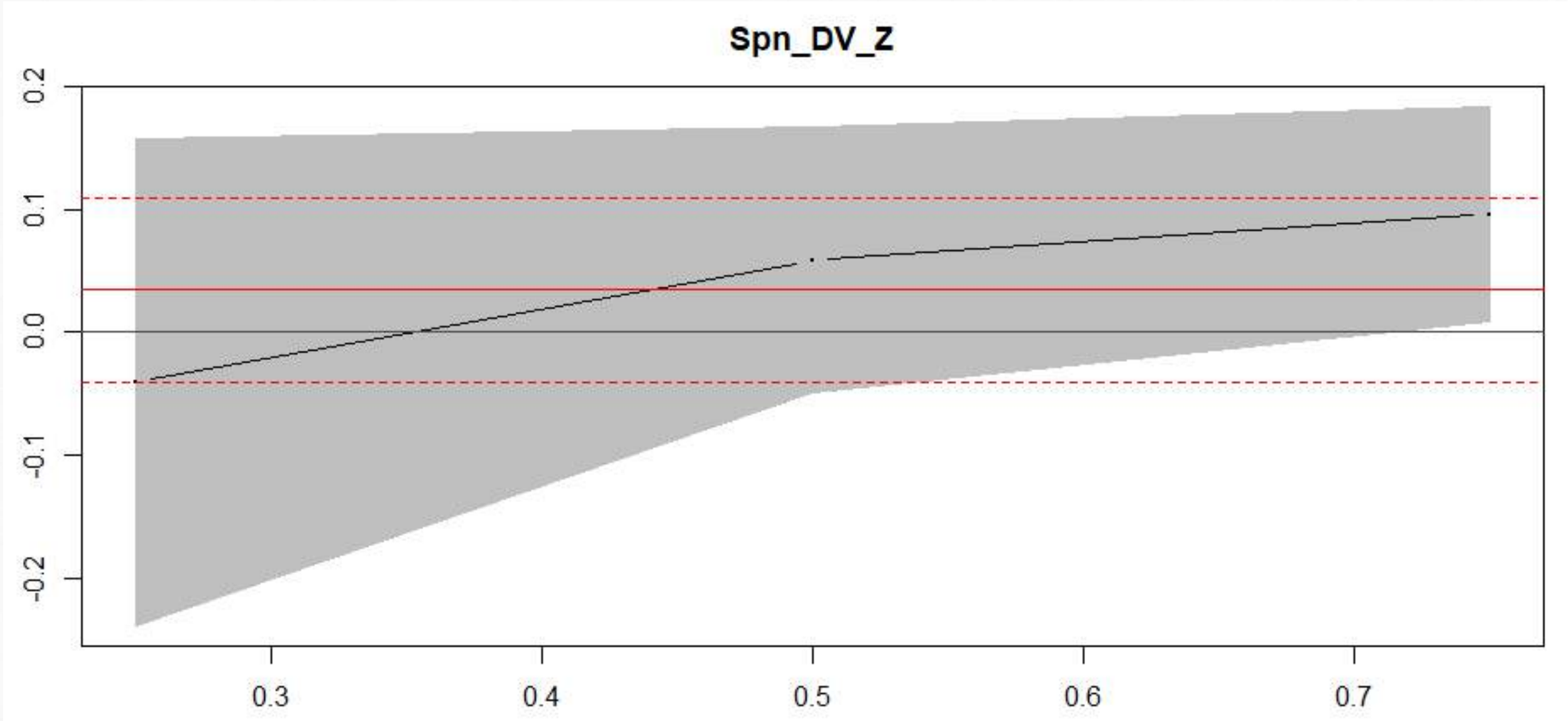
Using Quantile Regression to Investigate Cross-Language Transfer

- Results

	.25 Quantile	.50 Quantile	.75 Quantile	OLS Estimate
Oral Language	-.04	.06	.10*	.03

Using Quantile Regression to Investigate Cross-Language Transfer

- Results – Oral Language



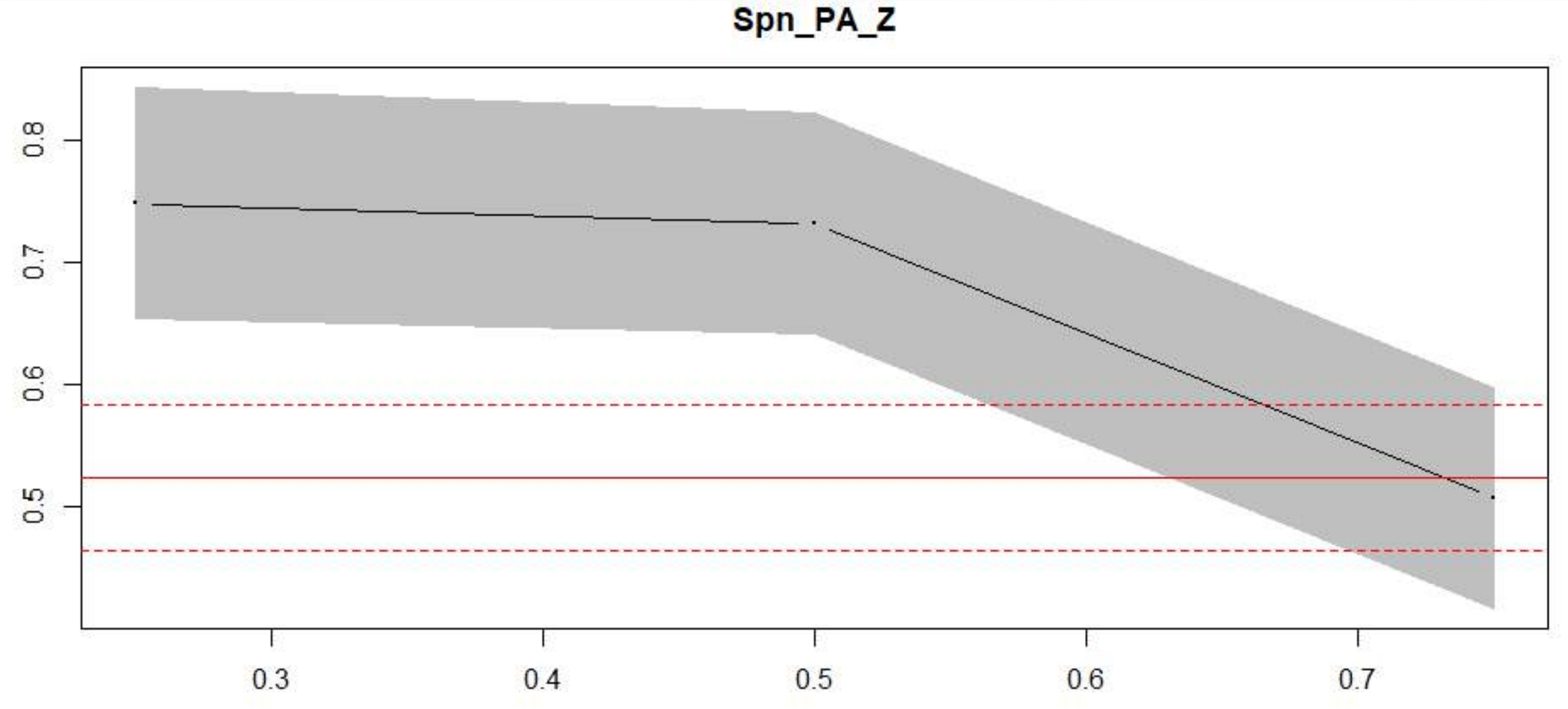
Using Quantile Regression to Investigate Cross-Language Transfer

- Results

	.25 Quantile	.50 Quantile	.75 Quantile	OLS Estimate
Oral Language	-.04	.06	.10*	.03
Phonological Awareness	.75***	.73***	.51***	.52***

Using Quantile Regression to Investigate Cross-Language Transfer

- Results – Phonological Awareness



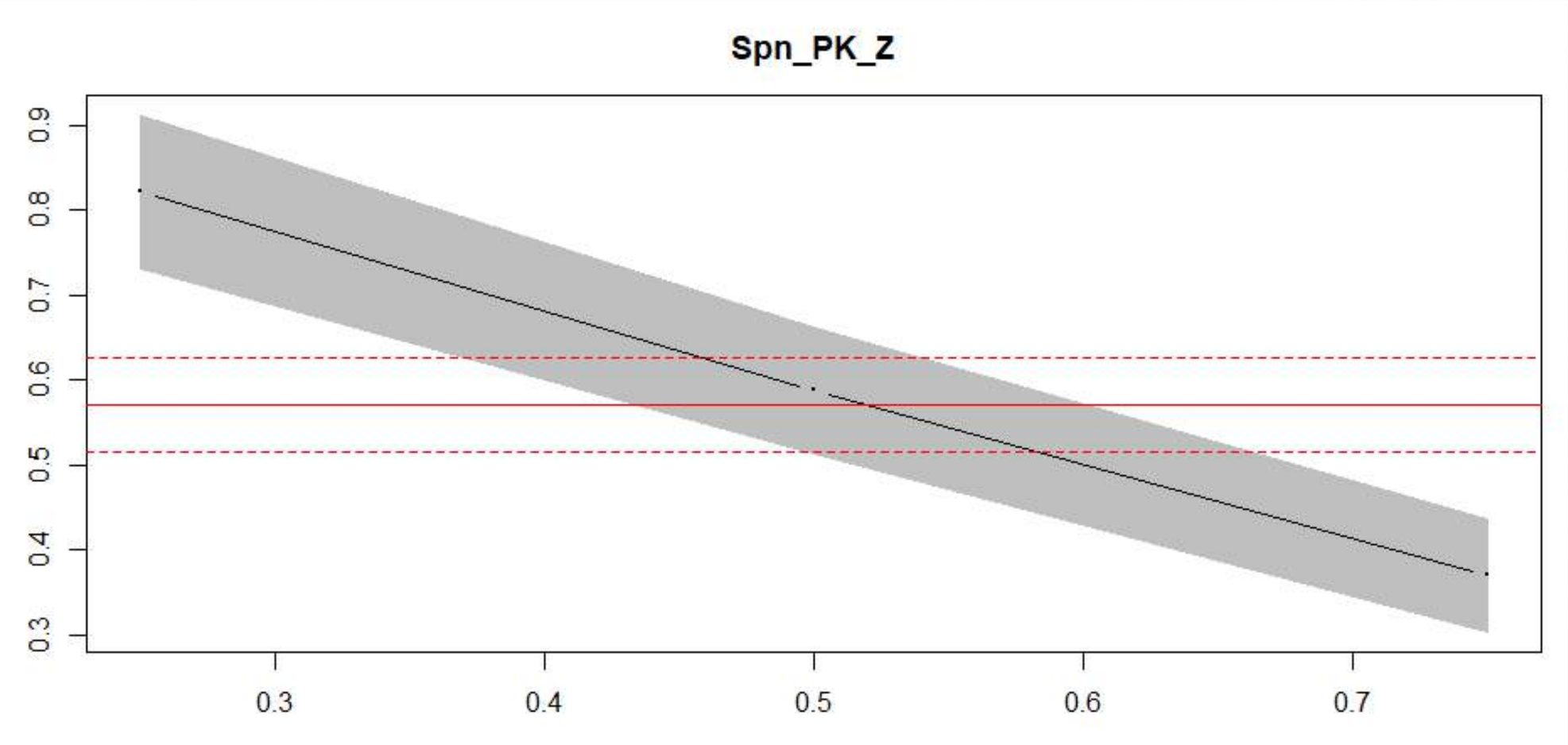
Using Quantile Regression to Investigate Cross-Language Transfer

- Results

	.25 Quantile	.50 Quantile	.75 Quantile	OLS Estimate
Oral Language	-.04	.06	.10*	.03
Phonological Awareness	.75***	.73***	.51***	.52***
Print Knowledge	.82***	.59***	.37***	.57***

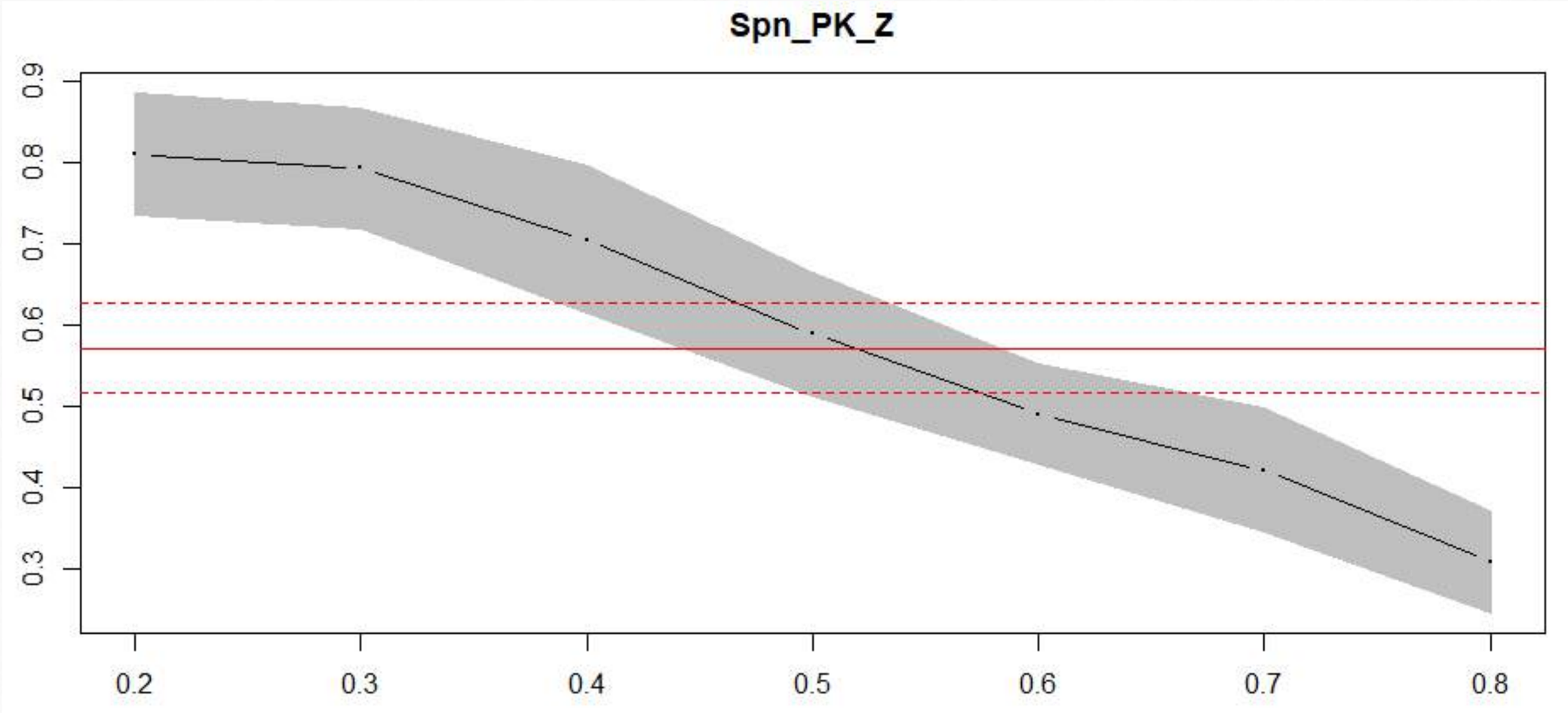
Using Quantile Regression to Investigate Cross-Language Transfer

- Results – Print Knowledge



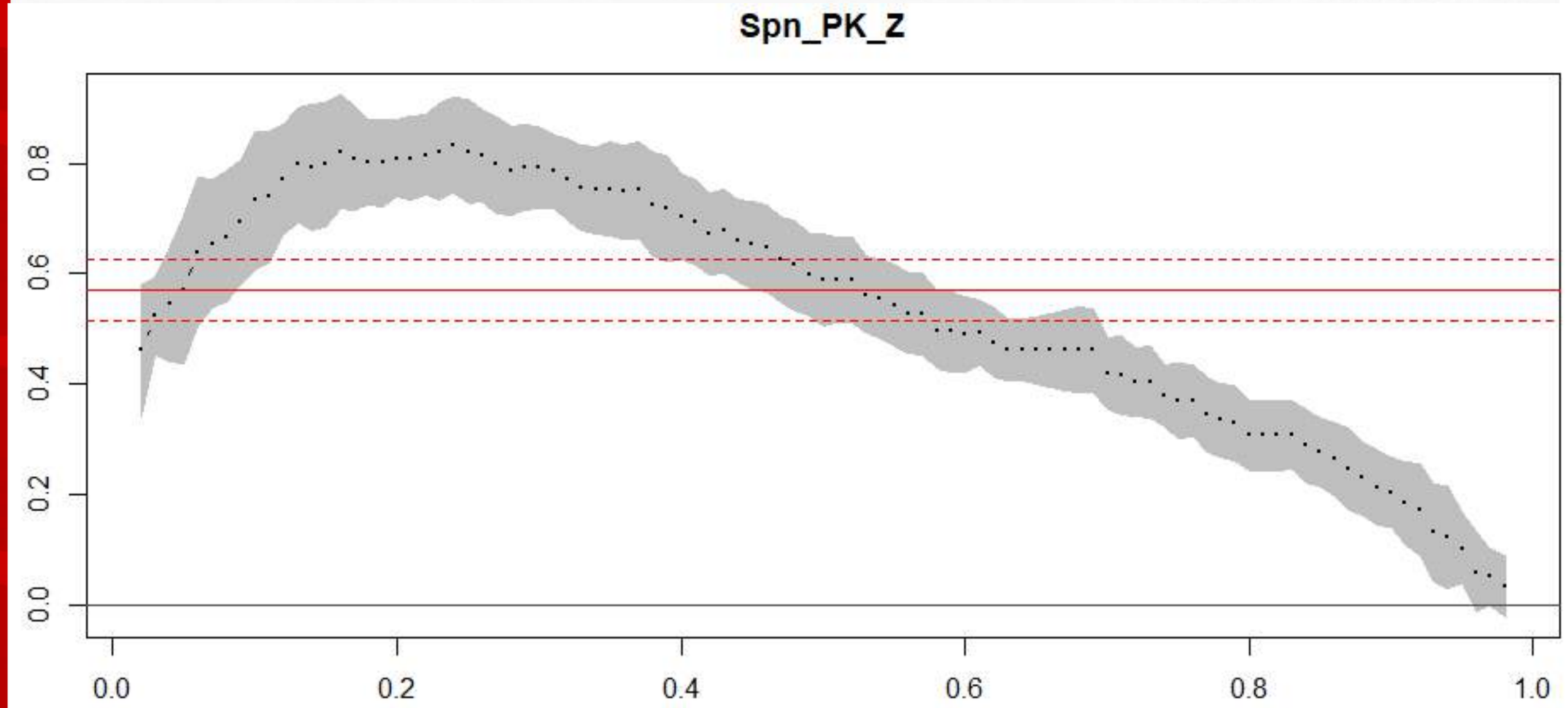
Examining Different Quantiles

- Results – Every 10th Quantile



Examining Different Quantiles

- Results – Every 100th Quantile



Quantile Regression

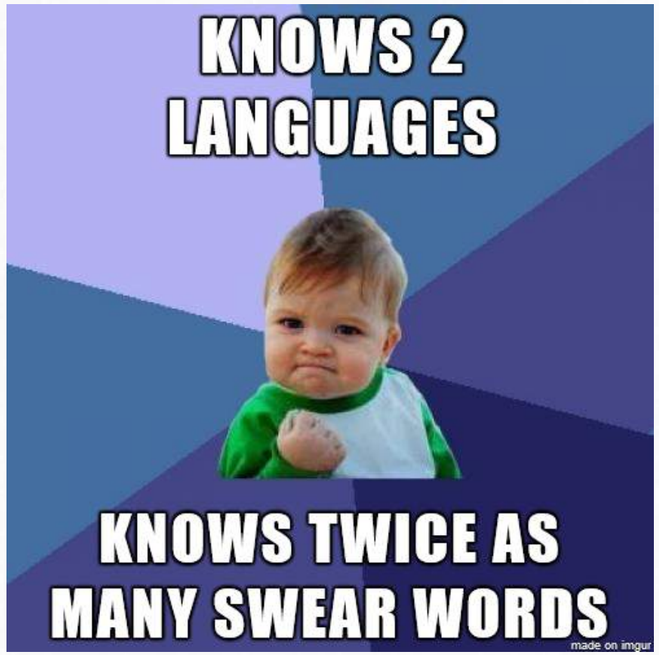
- Doesn’t rely on the assumptions of OLS regression (e.g., normally distributed residuals)
- Useful in educational research when floor or ceiling effects are present
- Can be easily implemented in several statistical software packages (e.g., R, SAS, Stata)
- However, some of the same interpretive limitations that exist for other correlational methods exist for quantile regression

Scale- versus item-level data

- DLLs often have lower single-language vocabulary knowledge than monolingual speakers of either language

- Can vocabulary knowledge be transferred across languages?

  - Maybe cognates?
  - What about *casa-house*?



Scale- versus item-level data

- Goodrich, Lonigan, Kleuver, & Farver (2016)
  - Does information regarding words known only in L1 provide unique information about future L2 vocabulary development?
  - Are children more likely to acquire L2 translation equivalents for words known in L1 than to acquire other words in L2?
- Method
  - Two samples (Ns = 96, 116)
  - Receptive and definitional vocabulary assessments completed at two time points in each sample

Scale- versus item-level data

- Often, evidence for cross-language correlations of vocabulary knowledge are often negative or non-significant
  - (Melby-Lervåg & Lervåg, 2011; Ordóñez, Carlo, Snow, & McLaughlin, 2002)

- To address this issue, conceptual vocabulary knowledge is used
  - Words known only in Spanish (L1)
  - Words known only in English (L2)
  - Words known in both languages

Scale- versus item-level data

- Scale-level data
  - Examining relations between L1 and L2 vocabulary using longitudinal multiple regression analysis

Results RQ1 – Scale-Level Data

Results of linear regression analyses examining effects of unique and combined vocabulary knowledge at time 1 on total vocabulary knowledge at time 2

	Receptive		Expressive		Definitional	
	Zero-order	Unique β	Zero-order	Unique β	Zero-order	Unique β
Sample 1			English outcomes			
Unique S	−0·58***	−0·10	−0·44***	0·06	−0·22*	0·04
Unique E	0·31**	0·43***	0·58***	0·81***	0·52***	0·61***
Combined	0·58***	0·66***	0·32**	0·59***	0·49***	0·56***
			Spanish outcomes			
Unique S	0·06	0·40**	0·57***	0·50***	0·64***	0·55***
Unique E	−0·35**	0·08	−0·55***	0·03	−0·35**	0·06
Combined	0·63***	0·80***	0·76***	0·71***	0·72***	0·61***
Sample 2			English outcomes			
Unique S	−0·52***	0·04	−0·64***	−0·14	−0·43***	0·21
Unique E	0·25**	0·46***	0·48***	0·66***	0·34***	0·73***
Combined	0·46***	0·62***	0·22*	0·53***	0·35***	0·69***

NOTE: S = Spanish; E = English; Zero-order = zero-order correlations; *** $p < .001$; ** $p < .01$; * $p < .05$.

Scale- versus item-level data

- Item-level data
  - Hierarchical generalized linear models
  - Items crossed with participants (every participant receives every item)
  - Predicting the probability of responding correctly to English vocabulary items at Time 2
  - Results reported as odds ratios

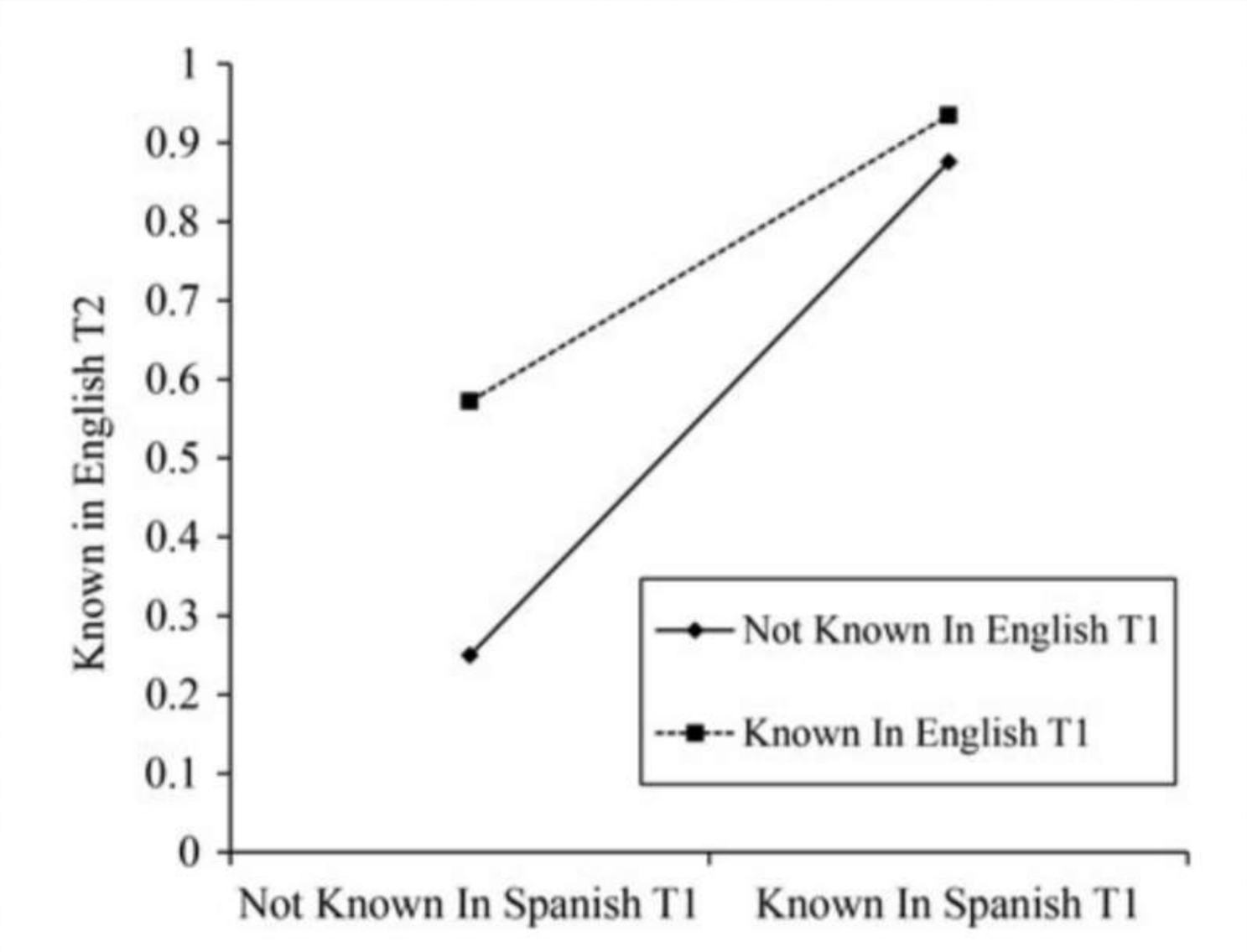
Results RQ2 – Item-Level Data

Odds ratios for the effects of English and Spanish vocabulary knowledge at time 1 on English and Spanish vocabulary outcomes at time 2 in Samples 1 and 2

	English outcomes			Spanish outcomes		
Sample 1	Receptive	Expressive	Definitional	Receptive	Expressive	Definitional
English	3·66***	21·02***	5·16***	1·65***	5·02***	2·69***
Spanish	1·72***	4·03***	3·31***	2·39***	23·62***	6·47***
ENG*SPN	1·57*	0·51**	1·03	1·75**	0·44**	1·32
Total ENG	1·06***	1·03**	1·06***	1·00	0·97**	0·99
Total SPN	0·98	0·98	0·99	1·05***	1·09***	1·11***
Sample 2						
English	3·68***	15·58***	4·83***			
Spanish	1·30*	3·32***	2·45***			
ENG*SPN	1·42	0·56**	0·73			
Total ENG	1·04**	1·03**	1·03**			
Total SPN	0·98	0·97**	0·99			

NOTE: English = whether the word was known in English at time 1; Spanish = whether the word was known in Spanish at time 1; ENG*SPN = interaction between whether the word was known in English and whether it was known in Spanish; Total ENG = total score on English vocabulary subtest; Total SPN = total score on Spanish vocabulary subtest; *** $p < .001$; ** $p < .01$; * $p < .05$.

Results RQ2 – Item-Level Data

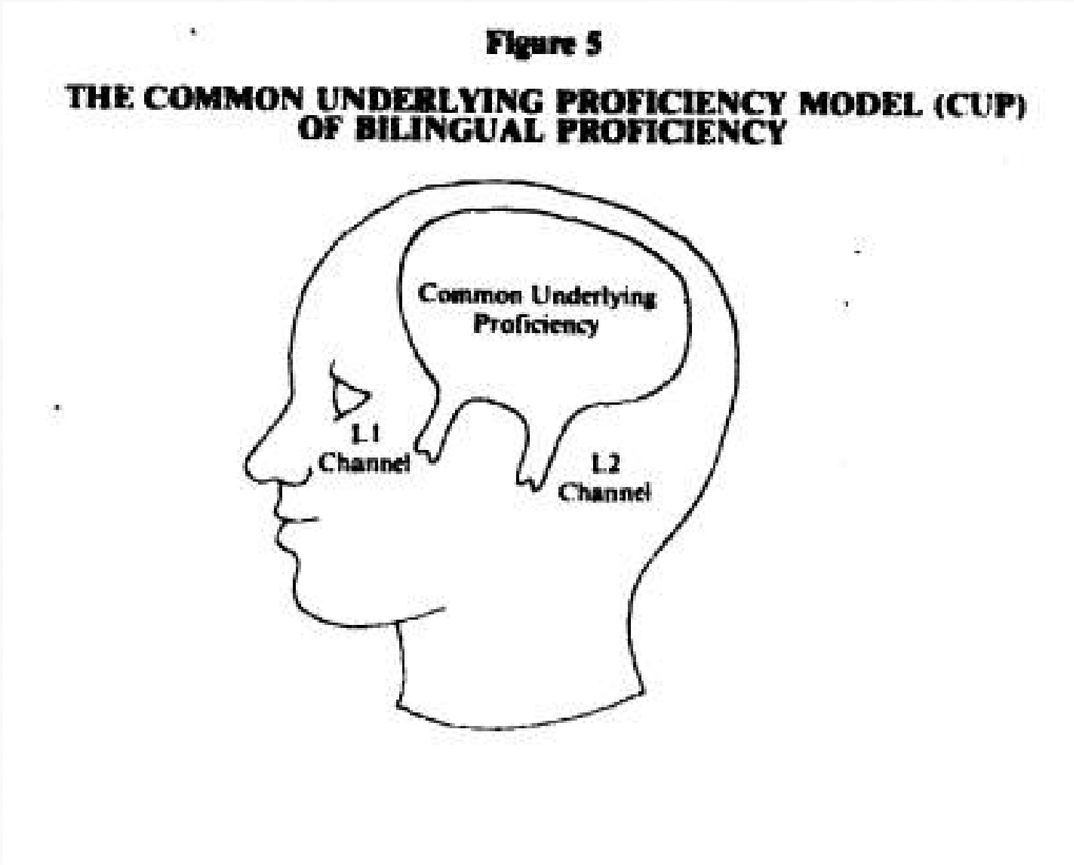


Scale- versus item-level data

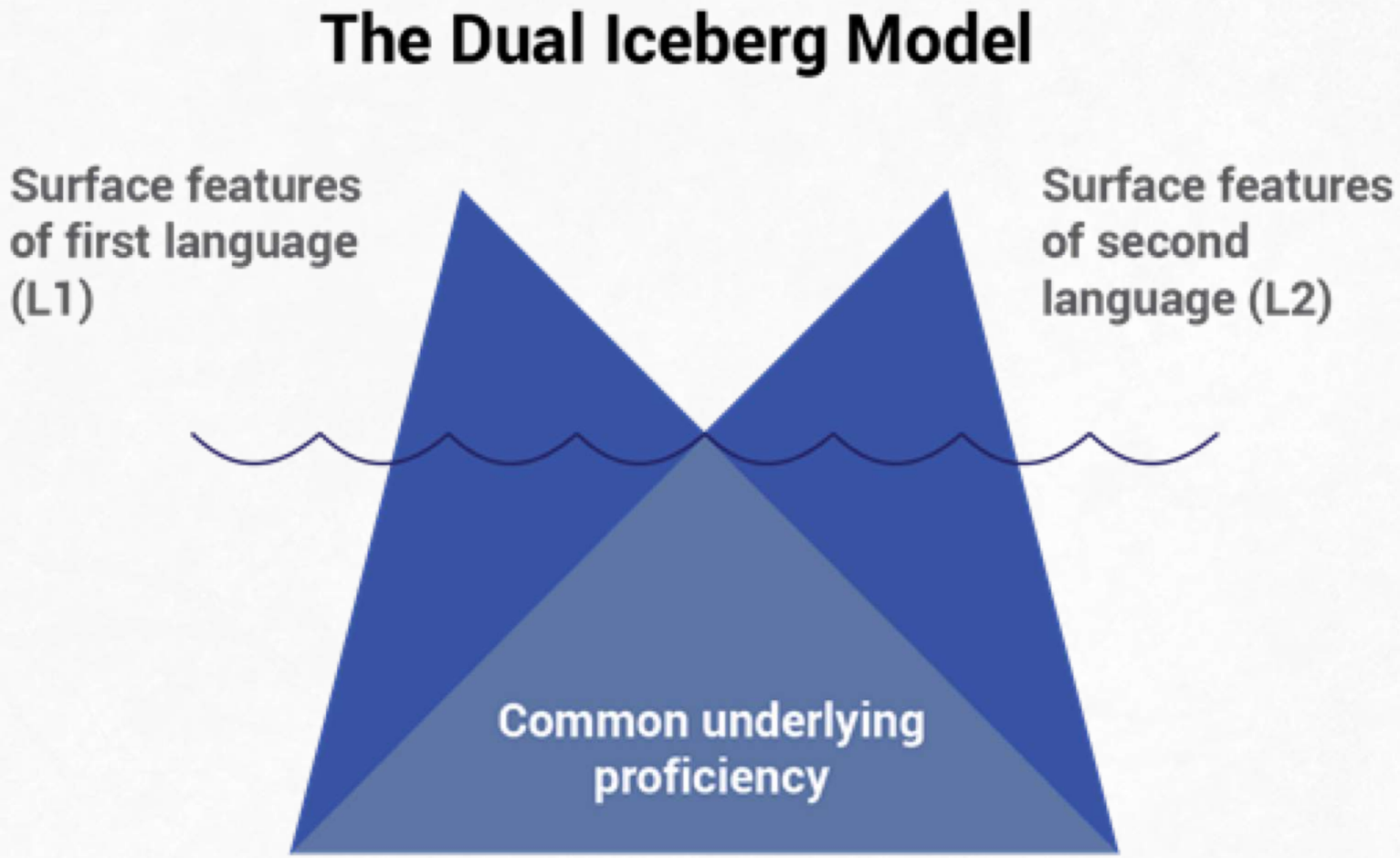
- When examining scale-level scores on vocabulary assessments, it appears that unique L1 vocabulary knowledge does not predict subsequent L2 development
- However, when examining whether individual words are known in L1, L2, or both, it becomes apparent that words known only in L1 are more likely to be acquired in L2 than are other words
- Answers to research questions may vary depending on the unit of analysis used
    - It is important to explore different approaches to examining data
    - Don’t fall into the trap of picking the approach that provides the answer you want

Latent Variable/Factor Analysis Approaches

- Back to theory!
- Common underlying proficiency model (Cummins, 1981; p. 24)

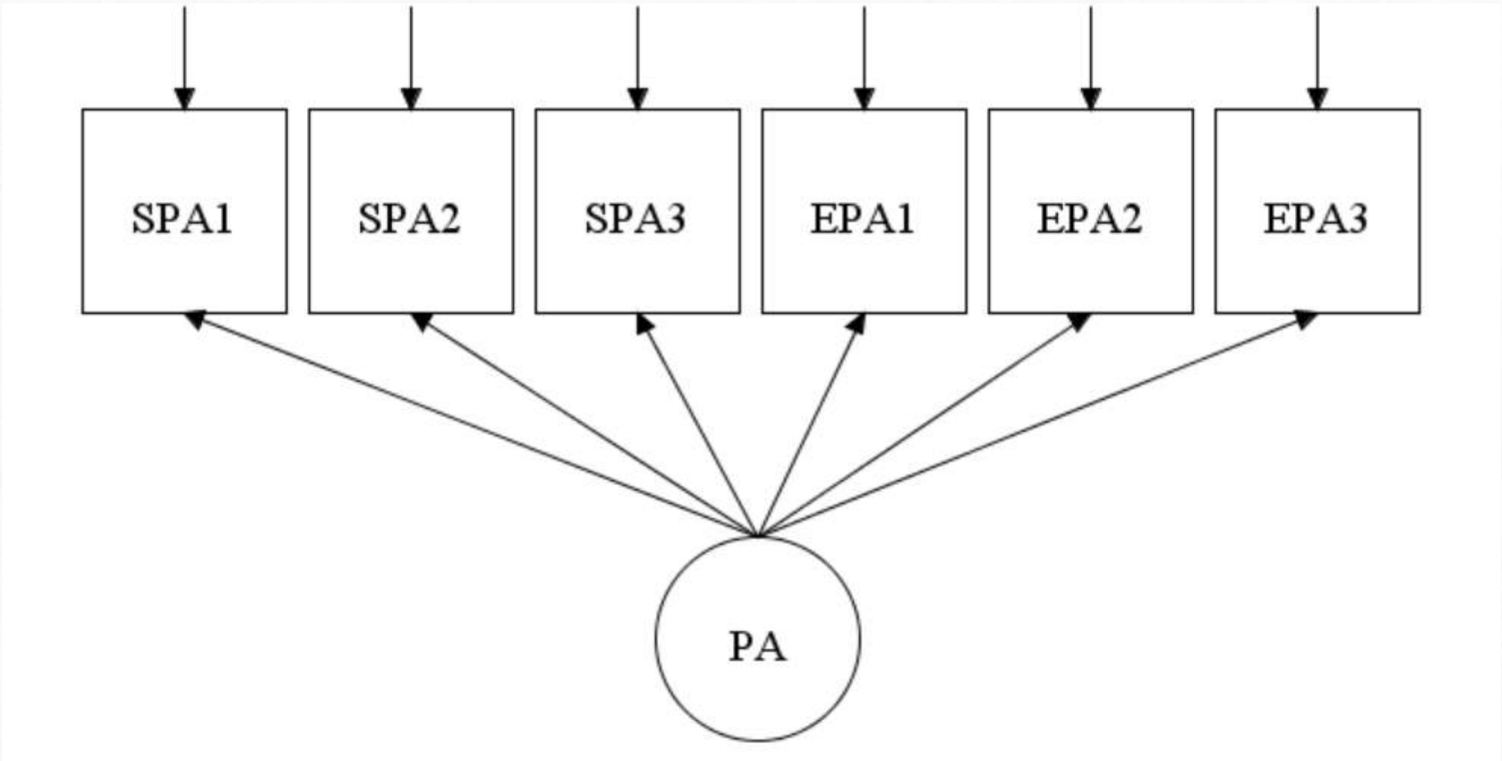


Common Underlying Proficiency Model (Cummins, 1981; p. 24)



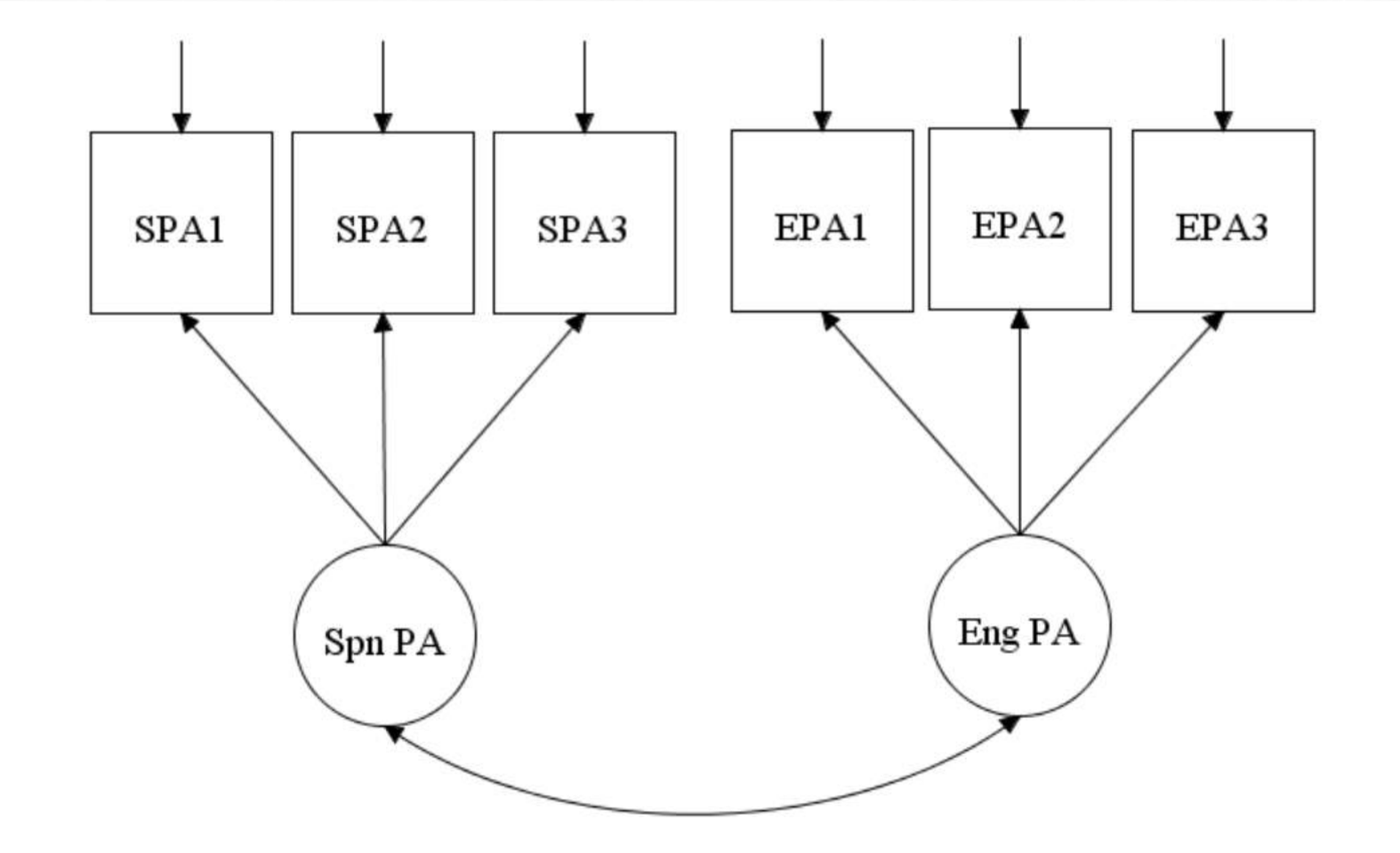
Latent Variable/Factor Analysis Approaches

- One way to test the common underlying proficiency is to use a bifactor modeling approach
- Traditional one-factor confirmatory factor analysis



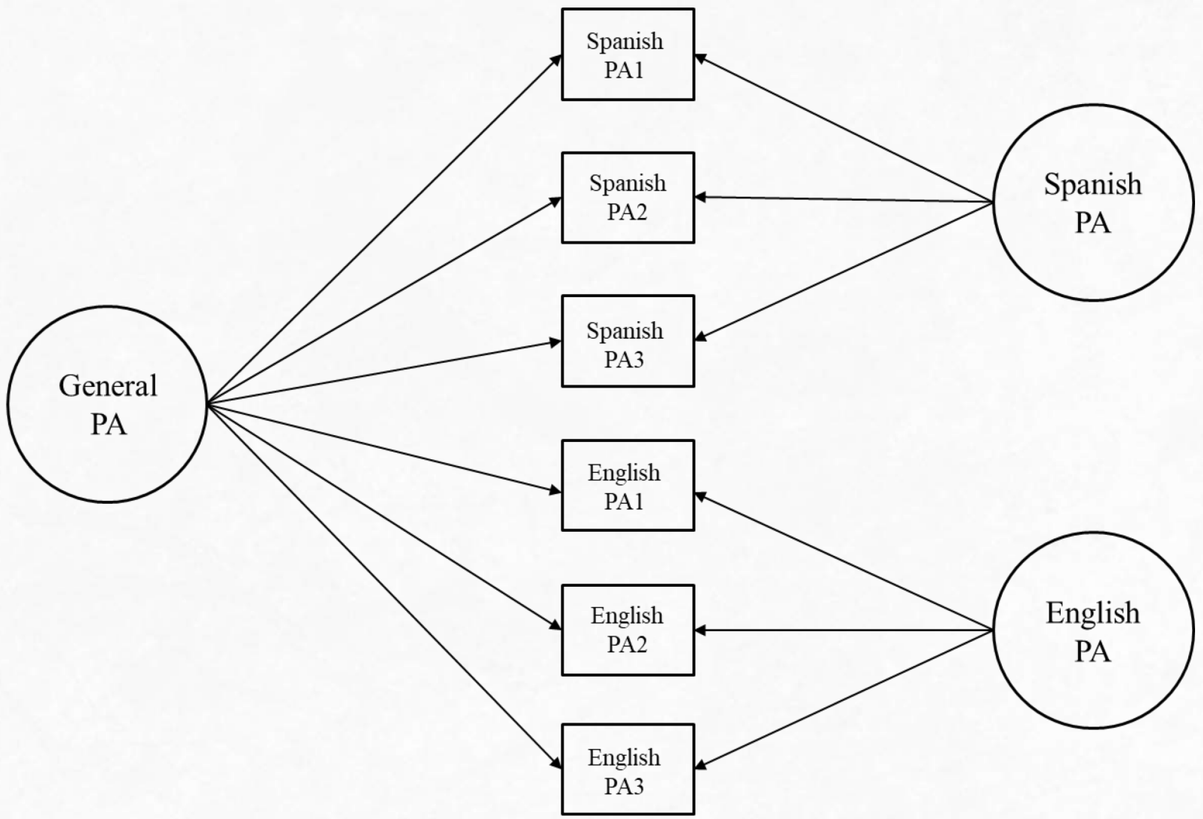
Latent Variable/Factor Analysis Approaches

- Two-factor model



Latent Variable/Factor Analysis Approaches

- Bifactor Model



Bifactor Model Results

- 858 Spanish-speaking preschoolers
- For phonological awareness and print knowledge, a bifactor model provided the best fit to the data
- For vocabulary, a two-factor model provided the best fit

Construct Model	Log Likelihood	AIC	ABIC	Parameters	Diff Test
Blending					
One Factor	−16319.19	32826.38	32971.79	94	
Two Factor	−15199.01	30588.02	30734.99	95	3230.50***
Bifactor	−14684.99	29651.99	29870.11	141	772.32***
Elision					
One Factor	−18172.21	36520.43	36656.56	88	
Two Factor	−17487.84	35153.69	35291.37	89	9046.54***
Bifactor	−16920.71	34105.429	34309.63	132	1226.36***
Print Knowledge					
One Factor	−27522.89	55333.78	55556.54	144	
Two Factor	−26246.81	52783.61	53007.92	145	340.53***
Bifactor	−24390.91	49213.82	49547.96	216	4578.71***
Expressive Vocabulary					
One Factor	−23763.92	47807.85	48024.76	140	
Two Factor	−21404.56	43091.12	43309.59	141	647.58***
Definitional Vocabulary					
One Factor	−27267.66	54815.33	55032.24	140	
Two Factor	−24779.49	49840.97	50059.43	141	44994.20***

Note. AIC = Akaike's Information Criterion. ABIC = Sample-size-adjusted Bayesian Information Criterion.

*** $p < .001$.

Determining Variance Accounted for in Bifactor Models (Rodriguez, Reise, & Haviland, 2016)

- Alpha versus omega
- Alpha has major limitations in the context of factor analysis
  - Assumes data are unidimensional (i.e., best represented by a single factor)
  - Assumes equal factor loadings across items (i.e., equal slopes between items and factor)
- Omega is based on the factor loadings of a specific model, and thus does not require that these assumptions are met

Omega Hierarchical (Rodriguez et al., 2016; pp. 141-142)

- Omega Total

$$\omega = \frac{(\sum\lambda_{gen})^2 + (\sum\lambda_{grp1})^2 + (\sum\lambda_{grp2})^2 + (\sum\lambda_{grp3})^2 + (\sum\lambda_{grp4})^2}{(\sum\lambda_{gen})^2 + (\sum\lambda_{grp1})^2 + (\sum\lambda_{grp2})^2 + (\sum\lambda_{grp3})^2 + (\sum\lambda_{grp4})^2 + \sum(1-h^2)}$$

- Omega Hierarchical

$$\omega_H = \frac{(\sum\lambda_{gen})^2}{(\sum\lambda_{gen})^2 + (\sum\lambda_{grp1})^2 + (\sum\lambda_{grp2})^2 + (\sum\lambda_{grp3})^2 + (\sum\lambda_{grp4})^2 + \sum(1-h^2)}$$

- Dividing OmegaH by OmegaT yields the percent of variance accounted for by any given factor

Omega (only one subscale); Rodriguez et al. (2016; pp. 141-142)

- Omega (subscale)

$$\omega_{} = \frac{(\sum \lambda_{ANX})^2 + (\sum \lambda_{PS})^2}{(\sum \lambda_{ANX})^2 + (\sum \lambda_{PS})^2 + \sum(1 - h^2)}$$

- Omega Hierarchical (subscale)

$$\omega_{HS.PS} = \frac{(\sum \lambda_{PS})^2}{(\sum \lambda_{ANX})^2 + (\sum \lambda_{PS})^2 + \sum(1 - h^2)}$$

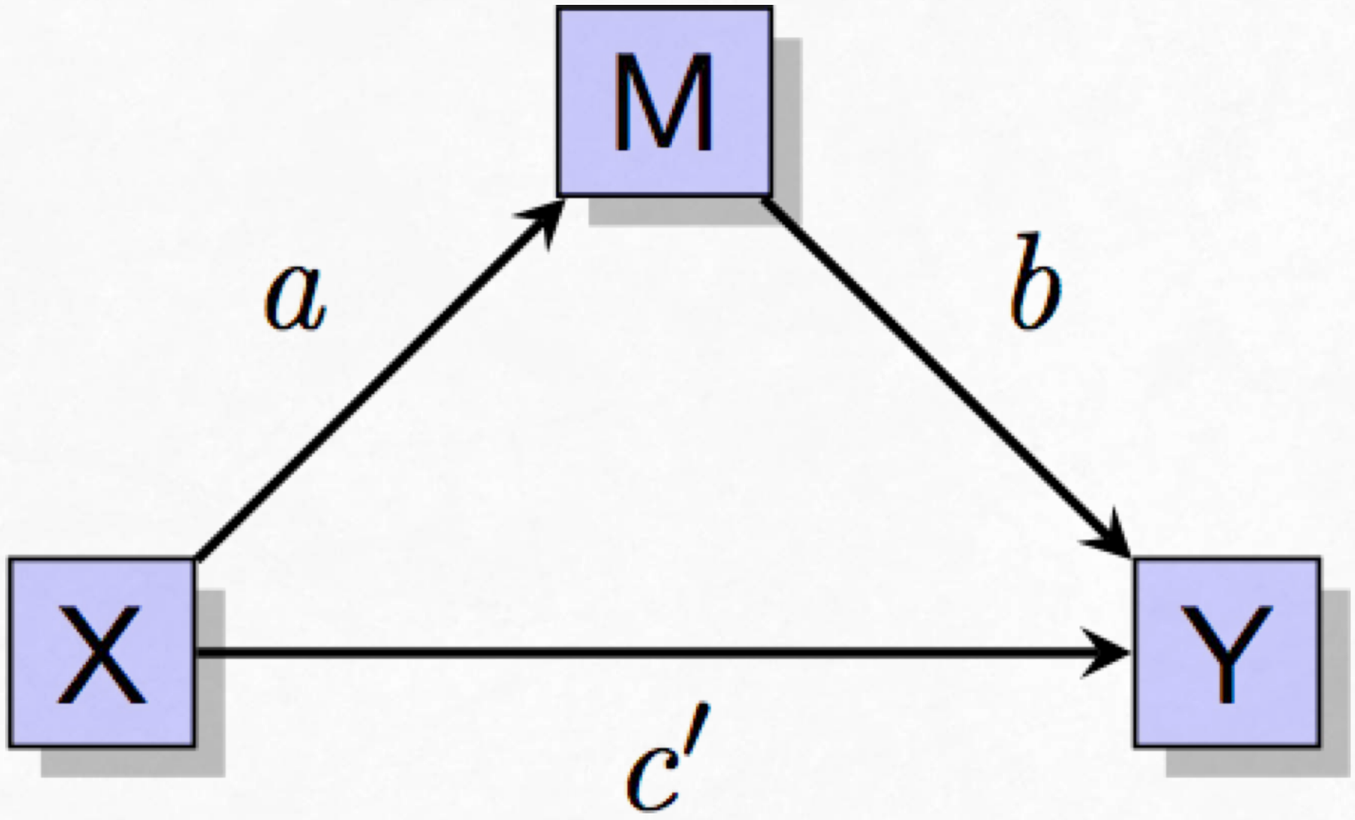
Omega Results

Omega values for bifactor models of early literacy.

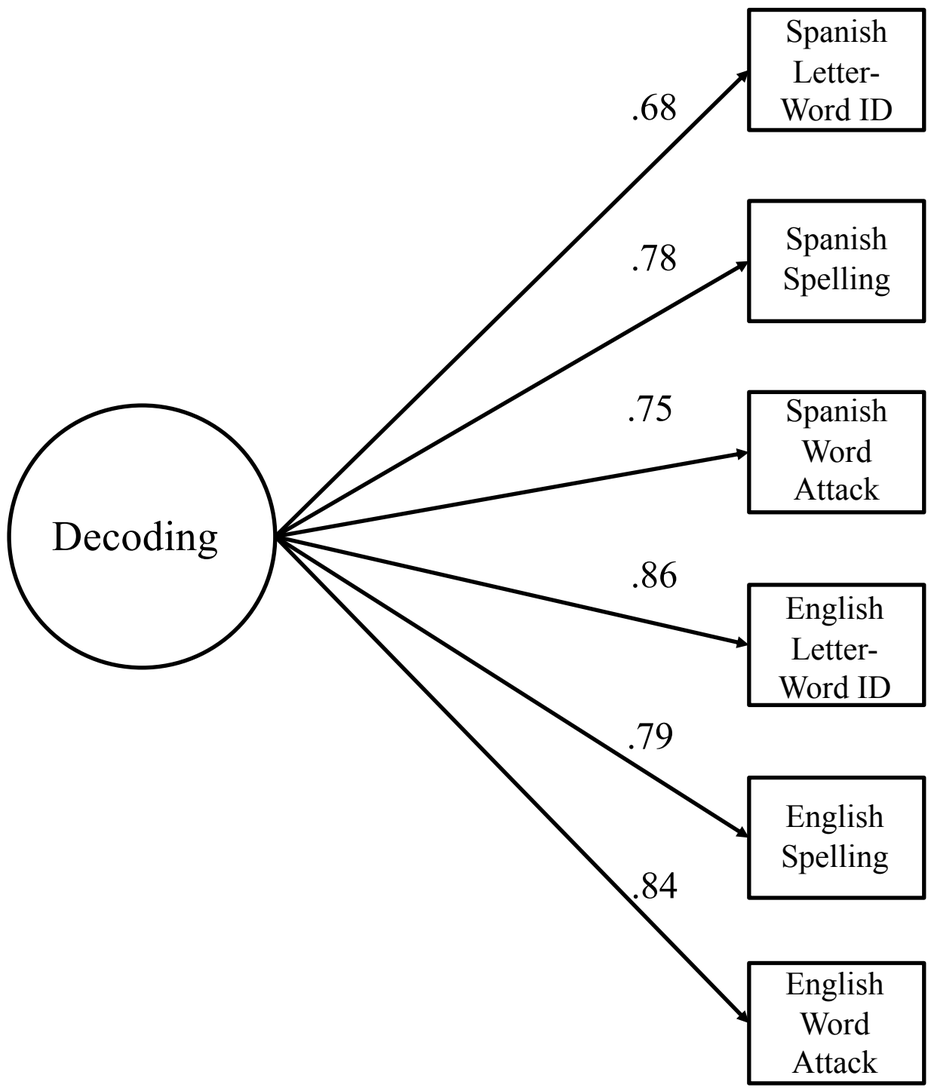
	Blending	Elision	Print
Omega Total	.98	.97	.98
Omega Hierarchical			
General Factor	.35	.44	.78
Spanish Factor	.52	.44	.17
English Factor	.12	.09	.03

Note. Dividing Omega Hierarchical by Omega Total yields the percent of variance in the total test score attributable to each factor. For each subset of items (i.e., Spanish and English). Dividing Omega Subscale by Omega yields the percent of variance in those items attributable to each factor.

Using Mediation Analysis to Examine Cross-Language Transfer in the Context of SEM

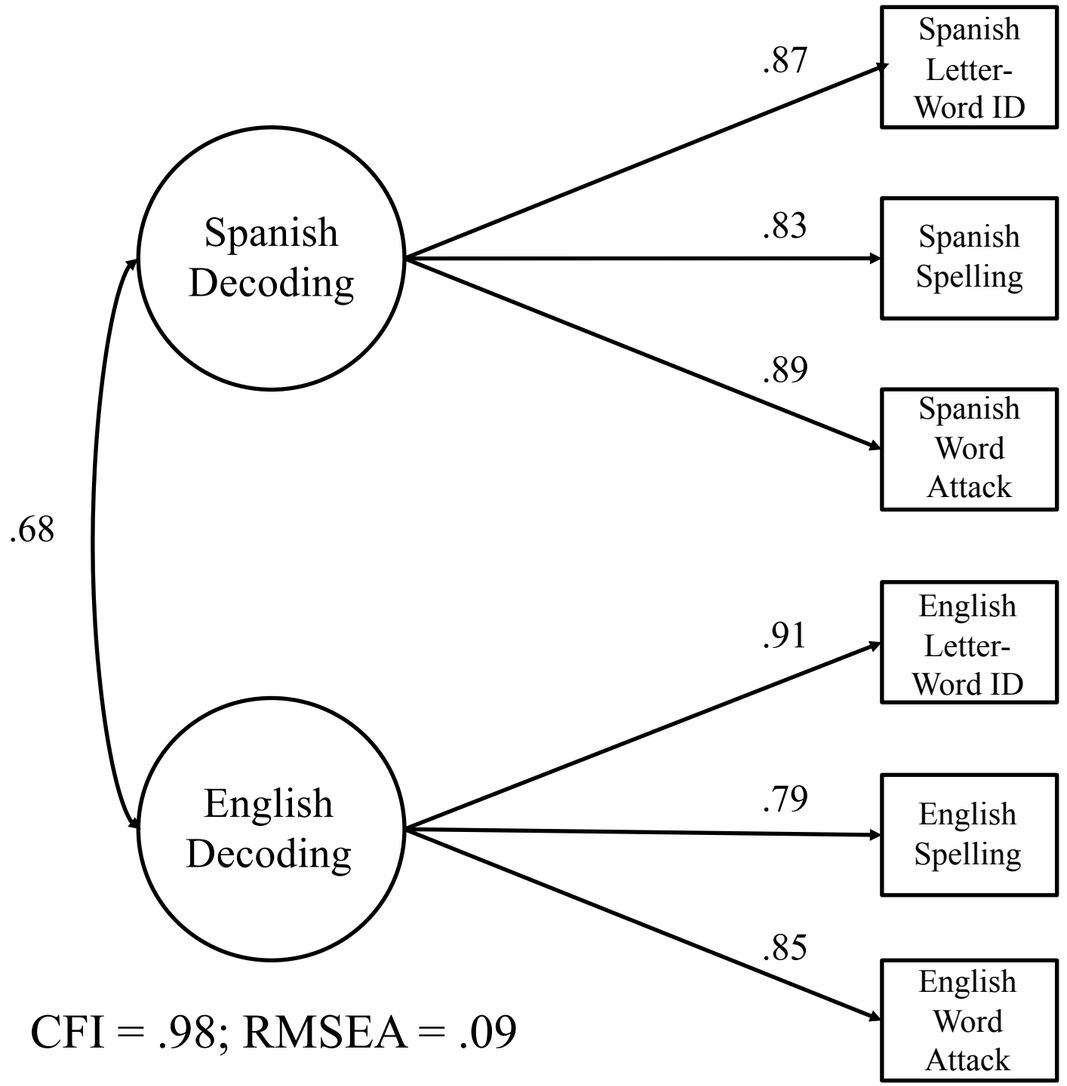


One-Factor Model -- Kindergarten



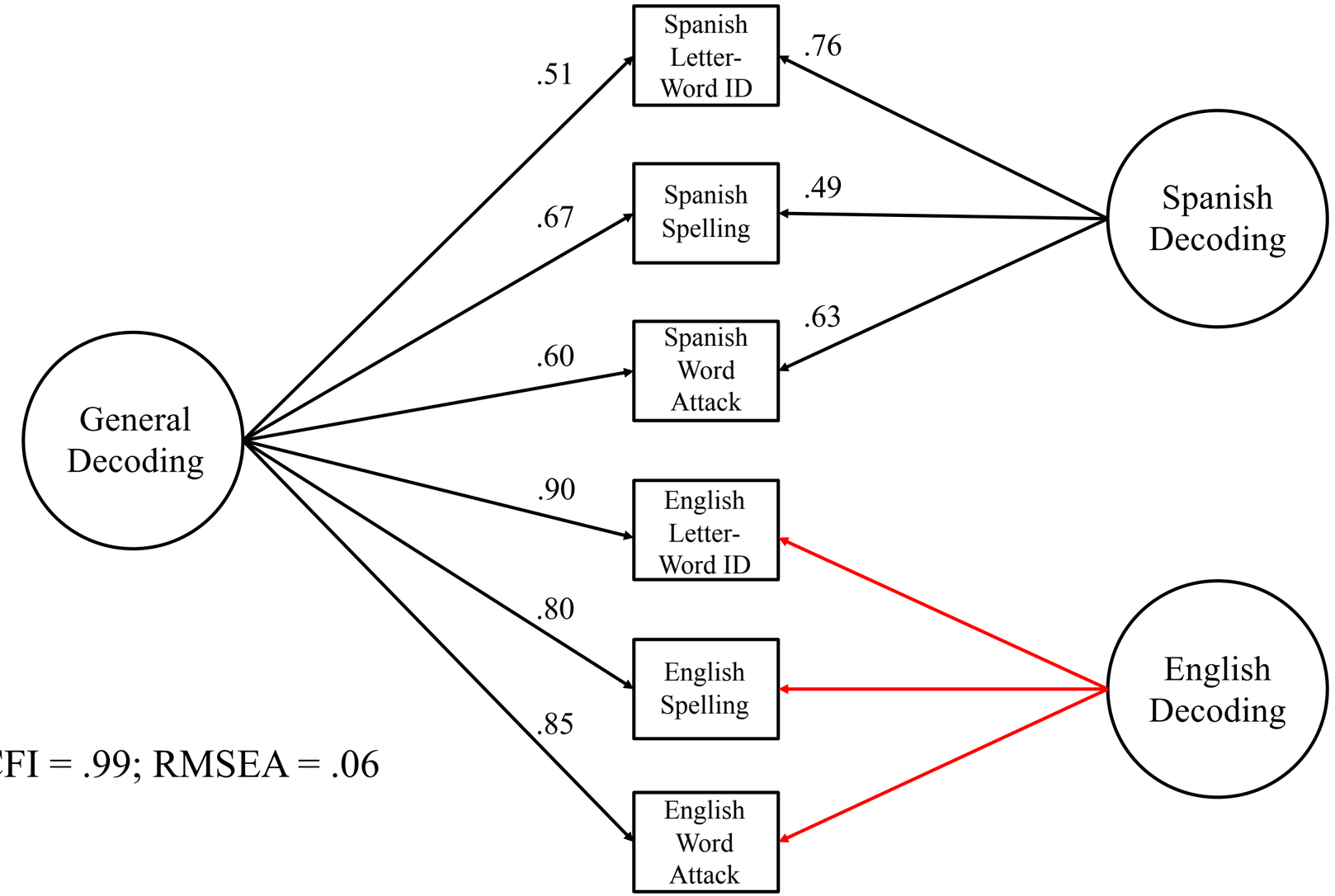
CFI = .84; RMSEA = .22

Two-Factor Model -- Kindergarten



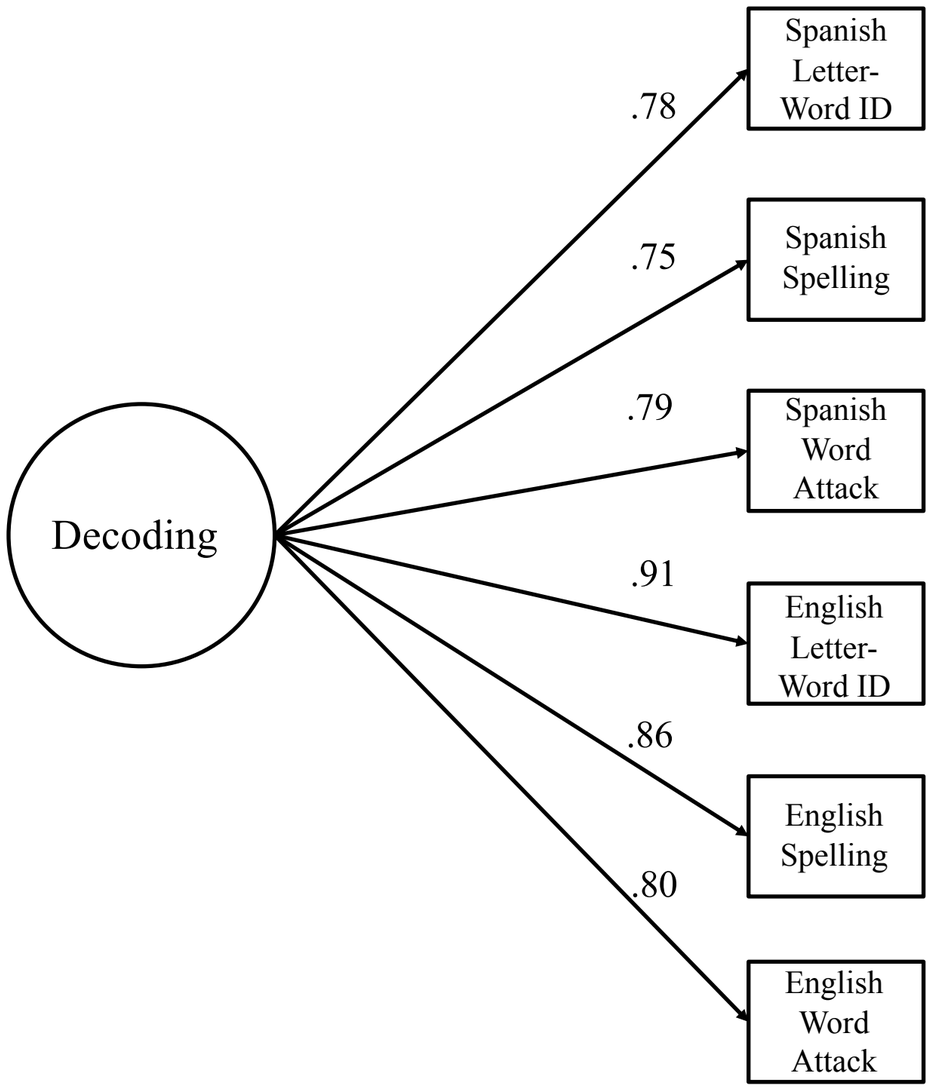
CFI = .98; RMSEA = .09

Bifactor Model -- Kindergarten



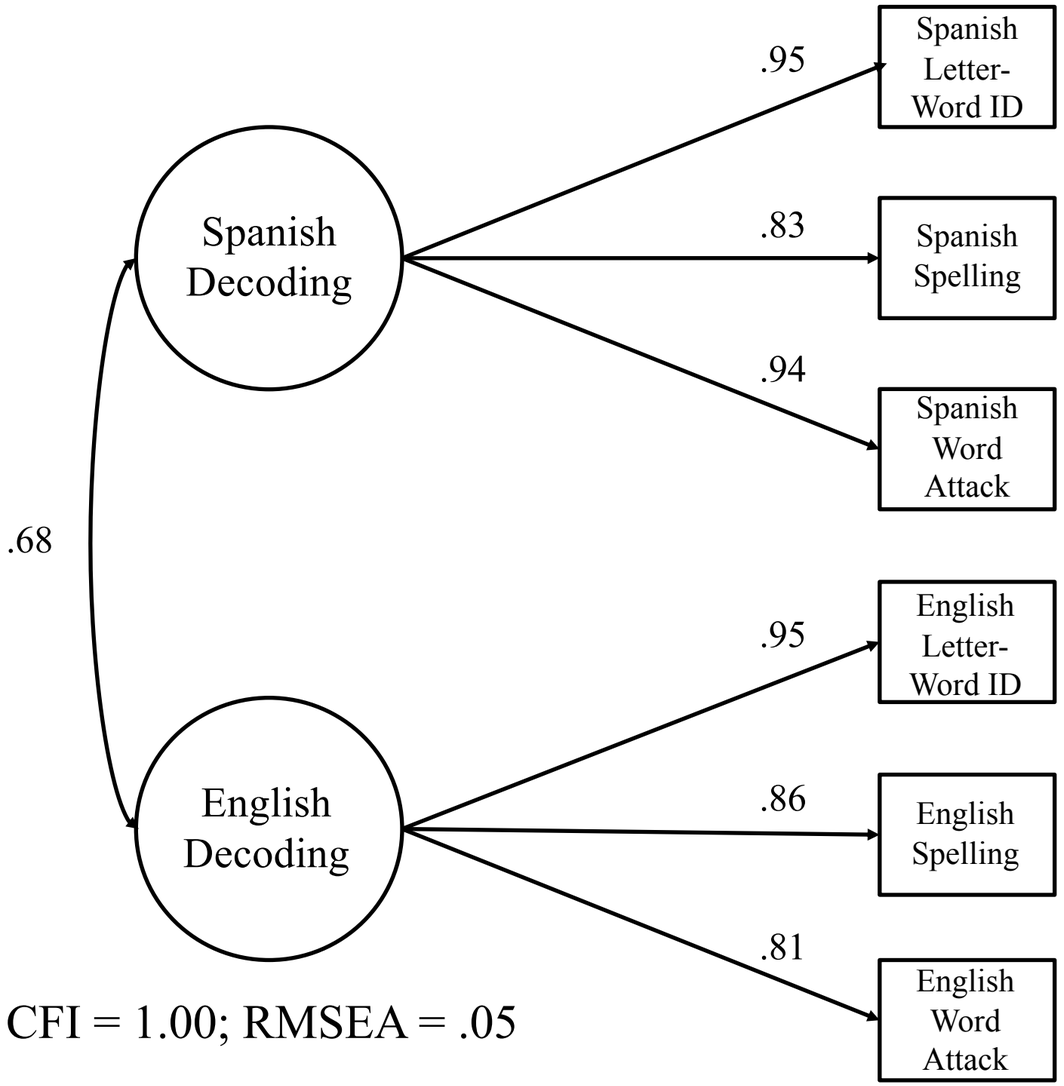
CFI = .99; RMSEA = .06

One-Factor Model – First Grade



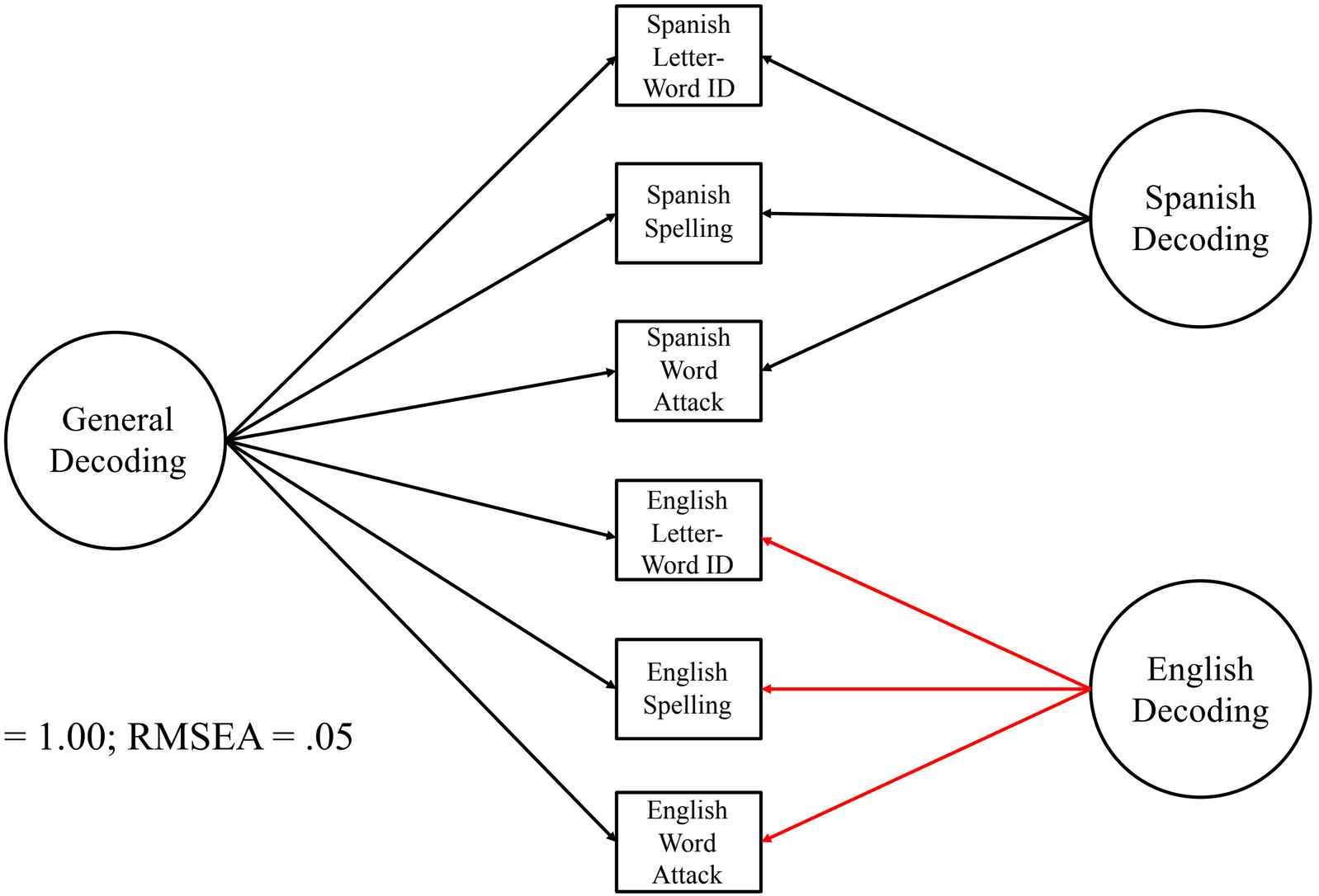
CFI = .80; RMSEA = .27

Two-Factor Model – First Grade



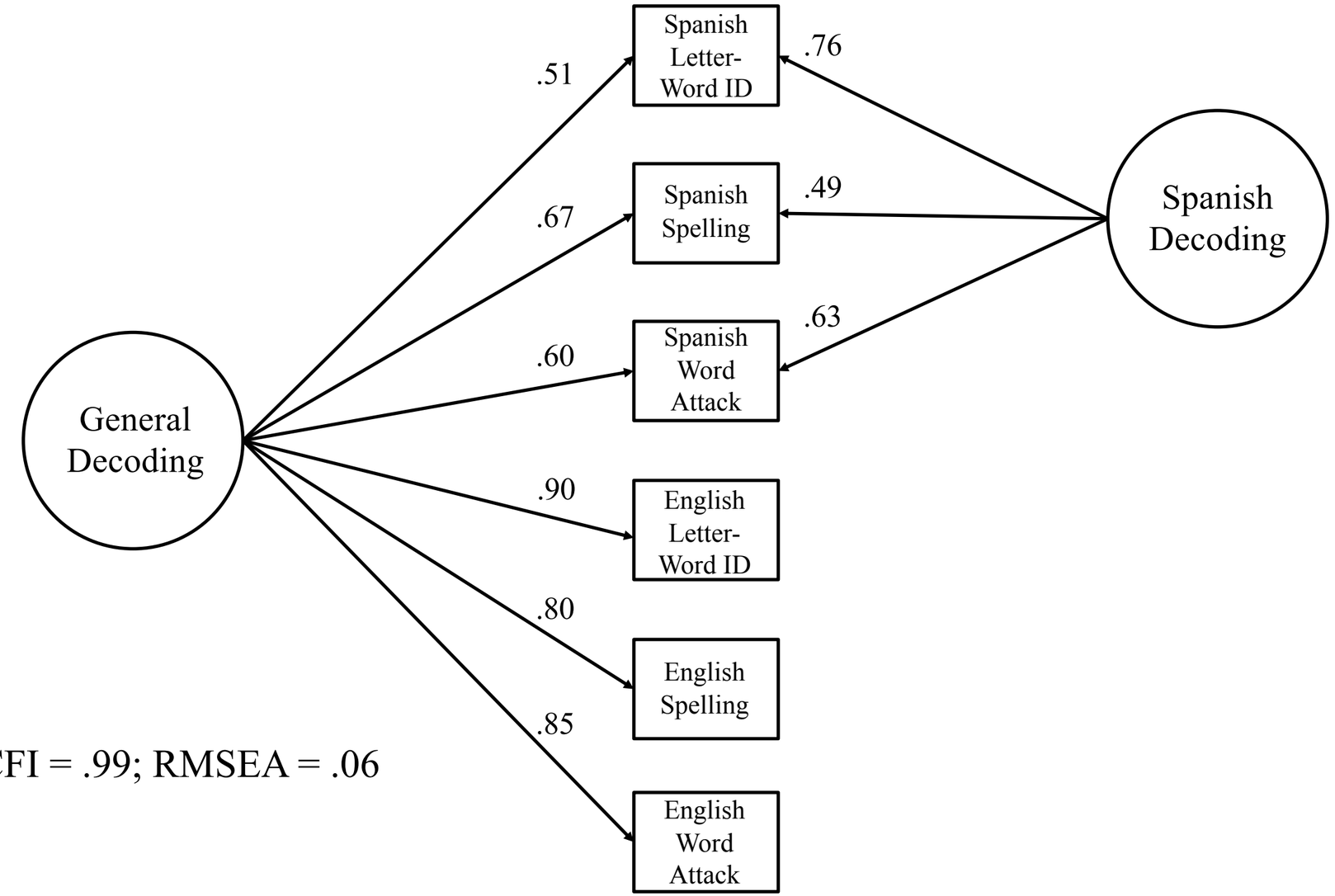
CFI = 1.00; RMSEA = .05

Bifactor Model – First Grade



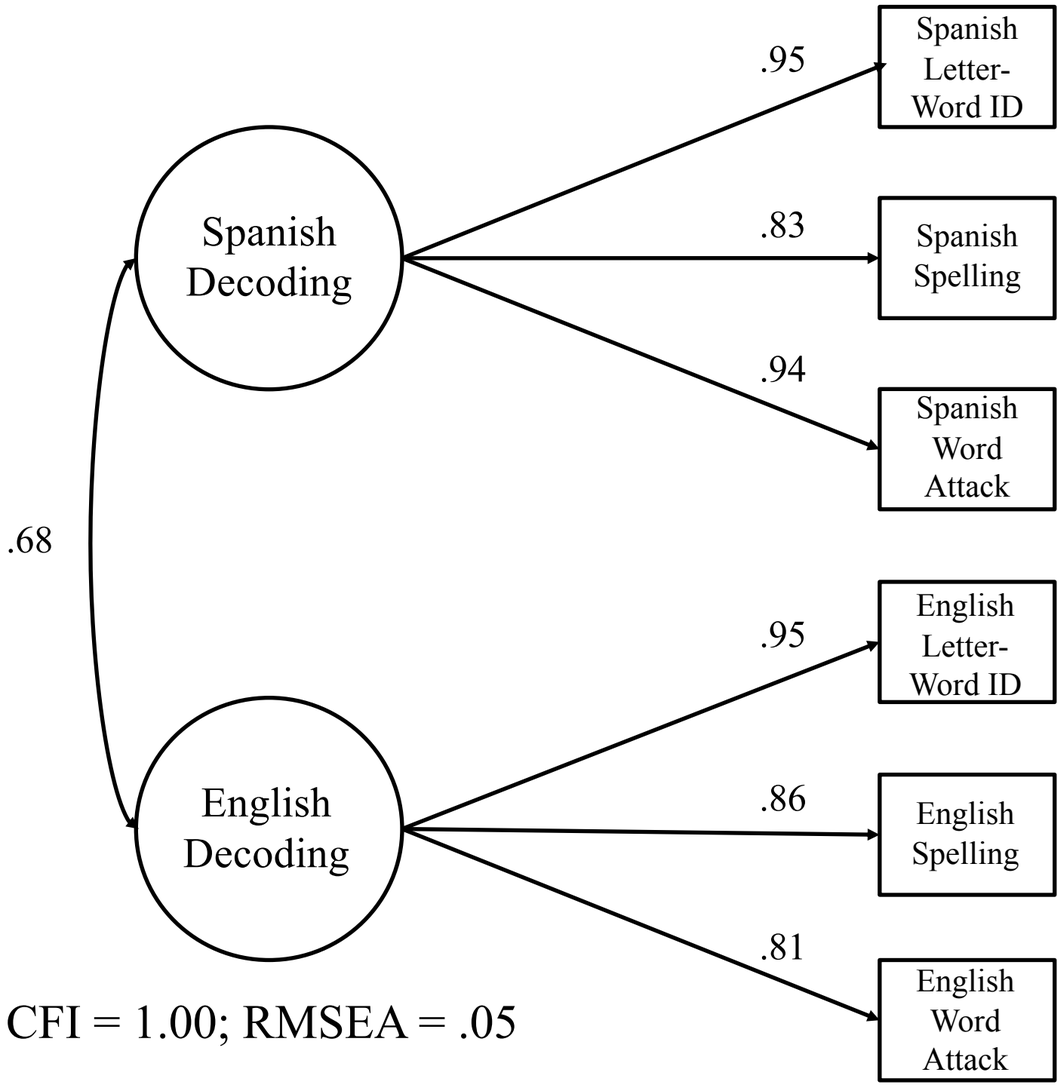
CFI = 1.00; RMSEA = .05

Final Model -- Kindergarten



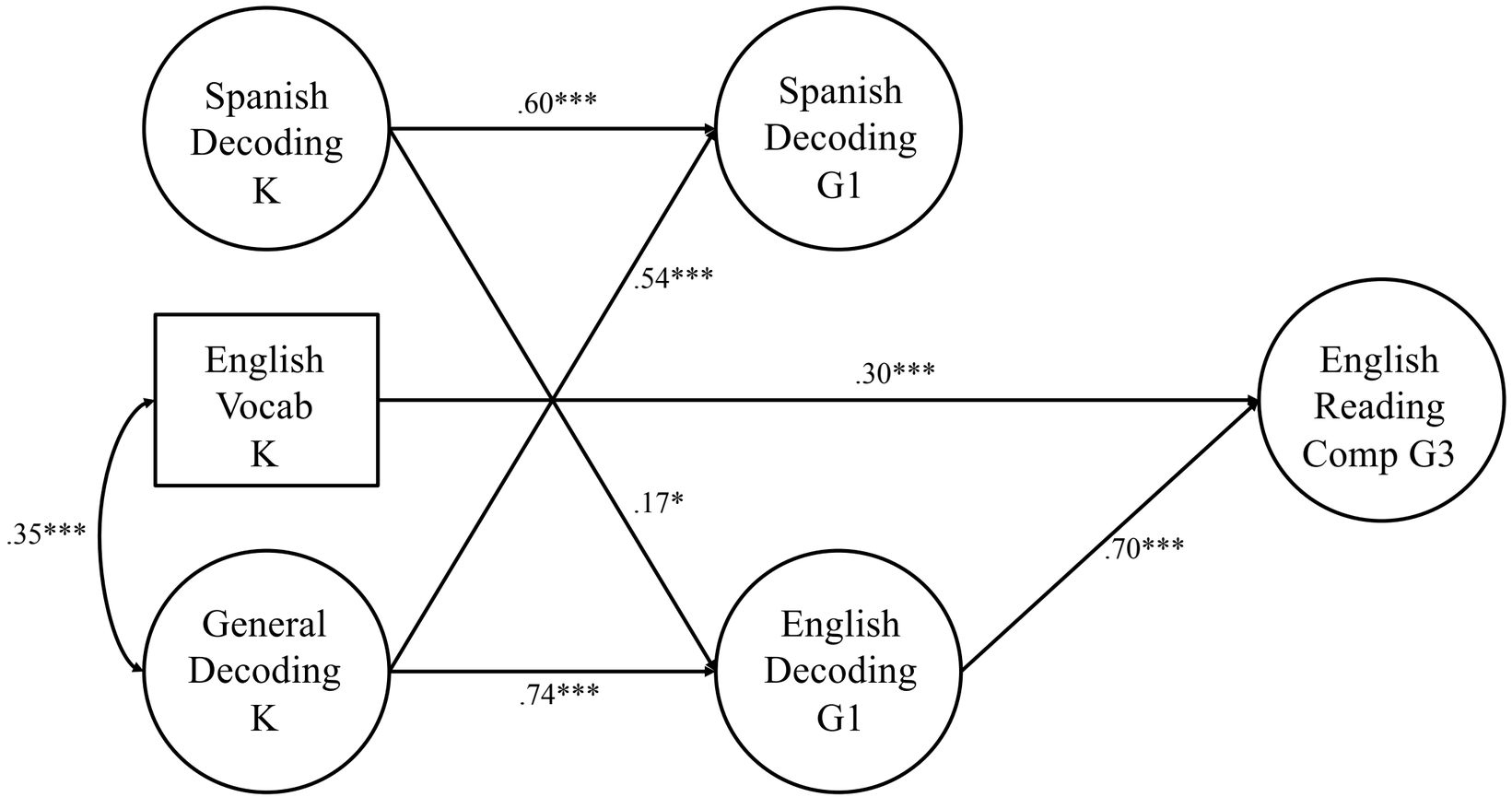
CFI = .99; RMSEA = .06

Final Model – First Grade



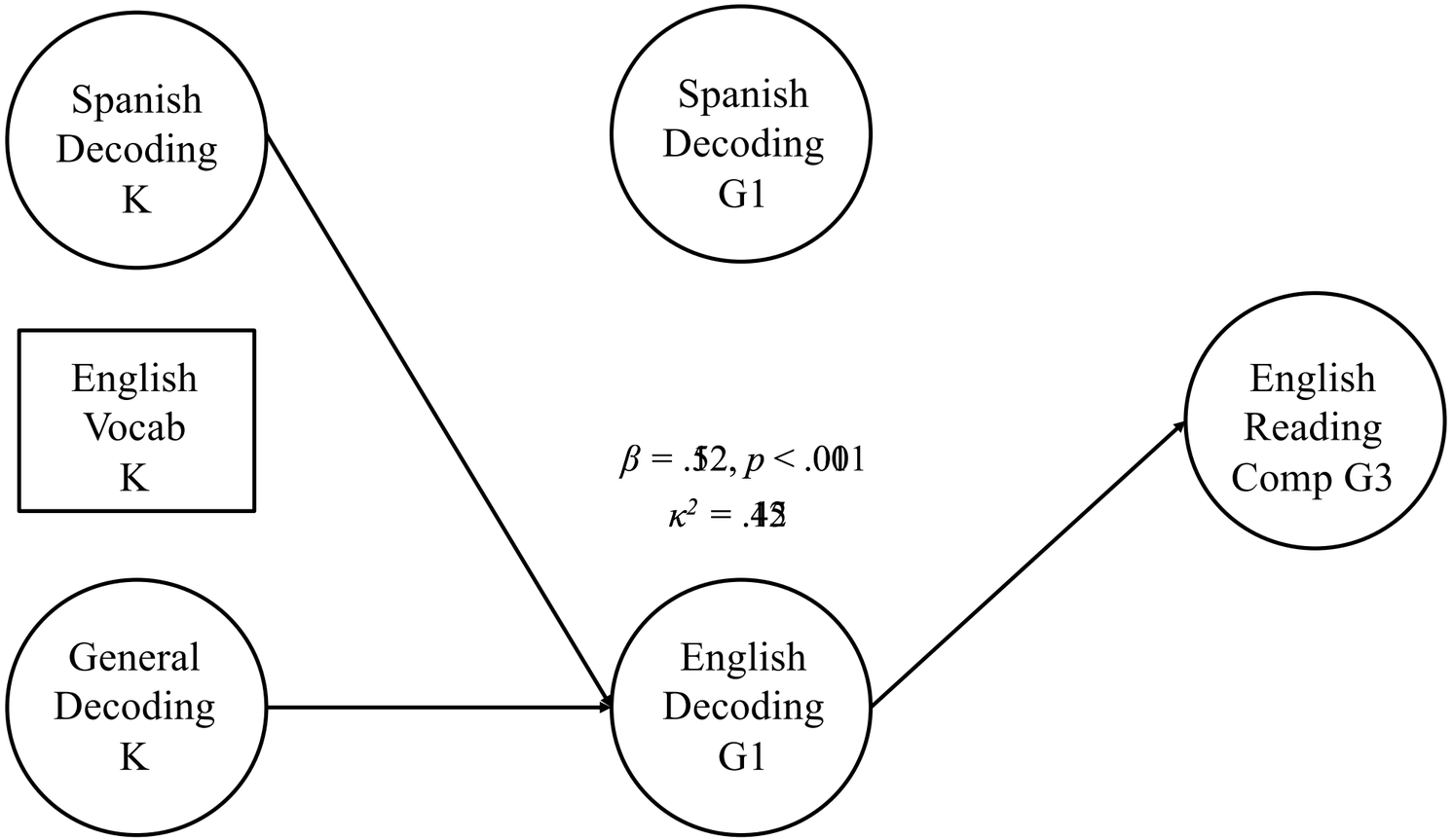
CFI = 1.00; RMSEA = .05

Final Structural Model – Significant Direct Effects



English Reading Comp G3 R^2 = .65; English Decoding G1 R^2 = .60; Spanish Decoding G1 R^2 = .63.

Final Structural Model – Significant Indirect Effects



Experimental Approaches to Evaluating Cross-Language Transfer

- Each of the prior correlational approaches represents a unique method of examining whether DLLs' L1 skills are related to their L2 skills
- However, a truer test of whether skills transfer across languages may come from experimental designs
- For example, if you randomly assign students to receive instruction in L1, and the treatment group outperforms the control group on L2 outcomes, this would represent evidence of transfer

Moderation of L2 Intervention by L1 Skills

- Additionally, if level of L1 skills at pretest moderates the impact of an intervention on L2 outcomes, this would suggest transfer
- Method – 96 Spanish-speaking DLLs received an early literacy intervention
    - Randomly assigned to receive early literacy instruction
- Examined whether impact of intervention varied for children with differing levels of Spanish early literacy skills

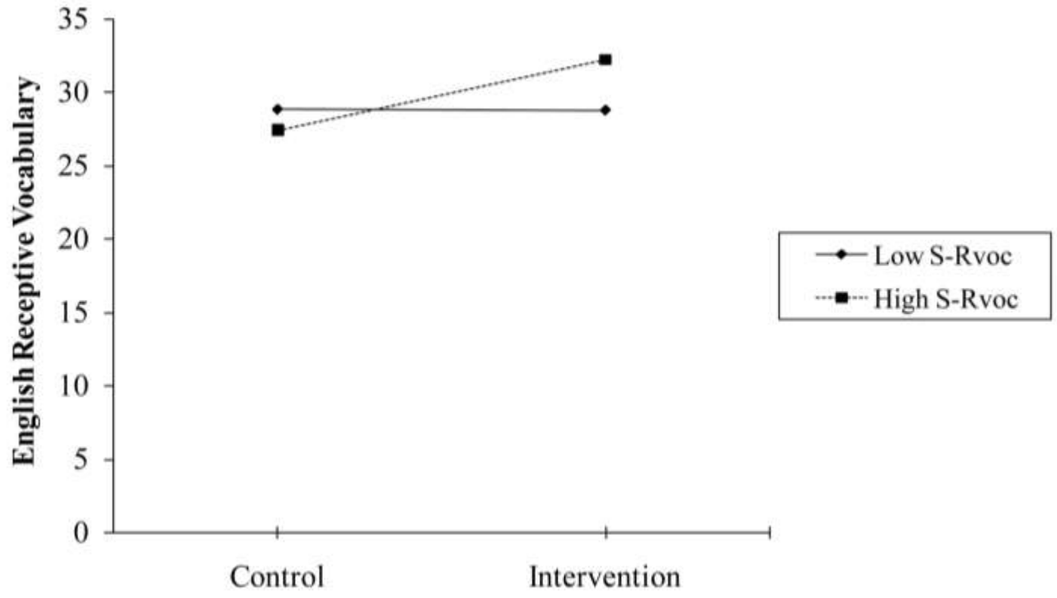
Moderation of L2 Intervention by L1 Skills

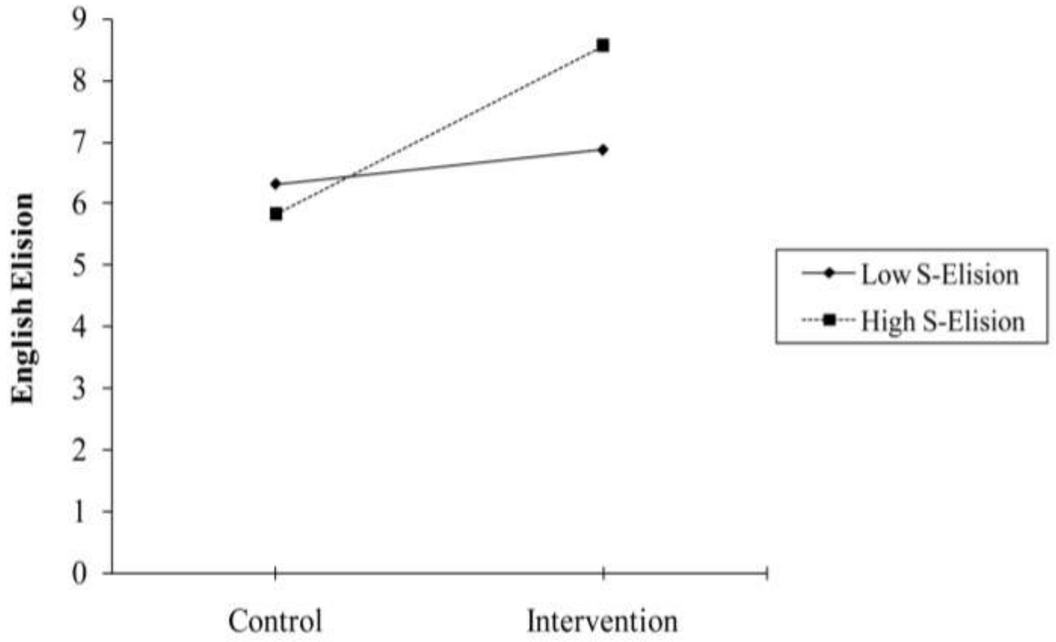
- Results

	Outcomes									
	RV		DV		Elision		Blending		PK	
Predictor Variables	**ΔR^2**	**B**	**ΔR^2**	**B**	**ΔR^2**	**B**	**ΔR^2**	**B**	**ΔR^2**	**B**
	English-Language Outcomes									
Step 1	.49***		.65***		.59***		.52***		.75***	
Intervention Condition		.20*		.19*		.30**		.23*		.17*
English Pretest		.67***		.77***		.53***		.61***		.62***
Spanish Pretest		.08		.11		.11		.21*		.28**
Step 2	.04*		.00		.04*		.01		.00	
Condition×S-Pretest		.21*		−.01		.16		−.07		−.06

Moderation of L2 Intervention by L1 Skills

- Results





Discussion and Conclusions

- Longitudinal mediation models or experimental evidence provide the strongest evidence of causal relations

- However, despite their limitations, the correlational methods presented provide unique insights into developmental phenomena

  - Moderation – Relations between X and Y vary based on Z
  - Quantile Regression – Relations between X and Y vary depending on the level of Y
  - Interesting patterns may only emerge in item- but not scale-level data (or vice versa)
  - Bifactor modeling – insights into multidimensionality of developmental constructs and variance in true test scores

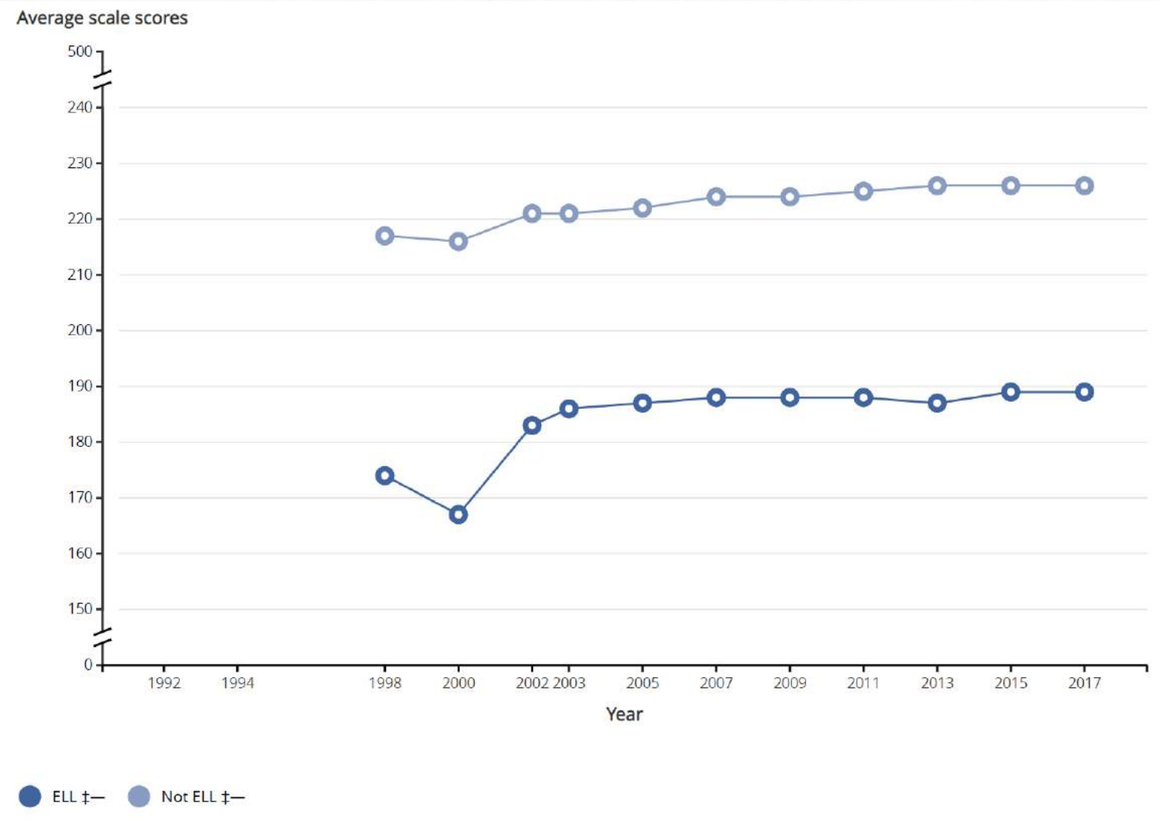
Discussion and Conclusions

- So, does cross-language transfer occur?
  - Maybe, depends on the particular skill, language exposure, instructional context, etc.
  - More research needed to determine how to leverage transfer to close the achievement gap

One Final Reason for Optimism

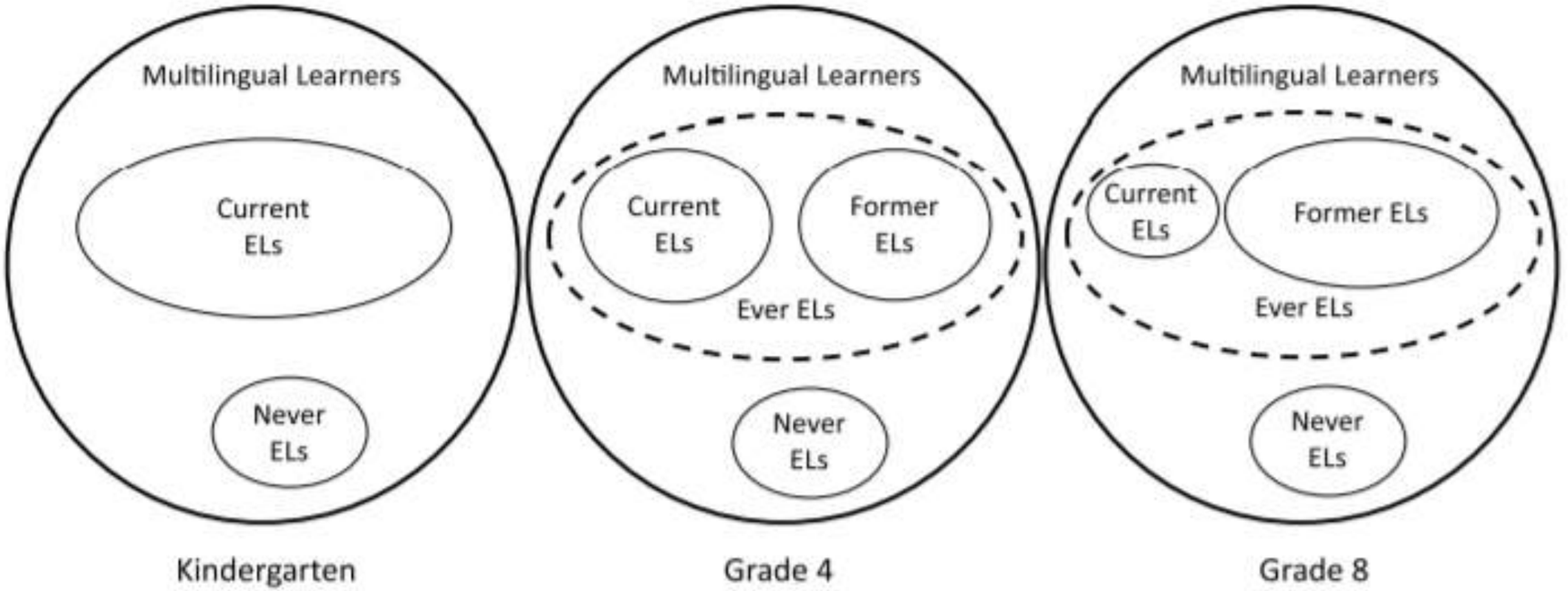
- Dual language learners (DLLs) have significantly lower academic achievement than do monolingual children across subjects and grades

- Reading achievement by ELL status at 4th grade



One Final Reason for Optimism

- Kieffer and Thompson (2018, p. 392)



One Final Reason for Optimism

- Kieffer and Thompson (2018, p. 396)

		Standardized Difference Between Monolingual and Multilingual Students	Change in Standardized Differences Since 2003
Grade 4 reading	2003	0.45***	
	2005	0.40***	–0.05
	2007	0.40***	–0.05
	2009	0.40***	–0.05
	2011	0.39***	–0.06
	2013	0.37***	–0.08
	2015	0.34***	–0.10

Acknowledgements

- Florida Center for Reading Research
- Preschool Research Group
- Numerous grad students and undergrad RAs
- Natalie Koziol and MAP Academy

Thank you!