Beyond the Simple View of Reading: The Role of Executive Functions in Emergent Bilinguals' and English Monolinguals' Reading Comprehension

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Abstract

The Simple View of Reading (SVR) describes reading as the product of decoding (D) and listening comprehension (LC; Gough, Hoover, & Peterson, 1996). However, the SVR has been challenged, and evidence has proved it to be too simple to explain the complexities of reading comprehension in the elementary school years. Hypotheses have been advanced that there are cognitive-linguistic factors that underlie the common variance between D and LC, which are malleable, although there is no clarity at this point regarding what these are. We propose that one such group of malleable cognitive factors is executive function (EF) skills. Further, we posit that EF skills play equally strong roles in explaining reading comprehension variance in emergent bilinguals (EBs) and English monolinguals (EMs). We used multigroup structural equation modeling to determine the contribution of these constructs (D, LC, and EF) to reading comprehension in 425 EBs and 302 EMs in Grades 2 through 4. The shared variance between D and LC was explained by direct and indirect effects in the models tested, with strong indirect effects for the EFs of cognitive flexibility and working memory through D and LC, respectively, for both language groups. The indirect effect of cognitive flexibility though LC on reading comprehension was considerably larger for EBs than for EMs. Considerations for a more nuanced view of the SVR and its implications for practice are discussed.

Beyond the Simple View: The Role of Executive Function in the Reading Comprehension of Emergent Bilinguals and English Monolinguals

Public discourse surrounding the Science of Reading has emphasized the Simple View of Reading (SVR; Gough & Tunmer, 1986) as a guiding framework for research under the Reading for Understanding (RfU) Initiative in the last decade (e.g., Cervetti et al., 2020) and beyond (Braze et al., 2016; Quinn & Wagner, 2018), and particularly for instructional practice (e.g. Hanford, 2018; *The Reading League Journal*, Volume 1, Issue 2, May/June 2020). From its introduction, the SVR was shown to explain reading comprehension not only in English Monolingual students (EMs) but also in Spanish-English Emergent Bilingual students (EBs; Hoover & Gough, 1990), leading to broad application of the SVR to inform instruction for all learners (e.g. in the United States, McGinty & Bevilacqua, 2016; in the United Kingdom, Rose, 2006).

The SVR posits that reading comprehension is the product of two independent processes, decoding and listening comprehension. Decoding (D) refers to the ability to apply letter-sound correspondences in reading words and, especially, pseudowords (Gough & Tunmer, 1986). In contemporary work, D is typically operationalized as word reading, and listening comprehension is typically operationalized as linguistic comprehension (LC), which refers to the ability to take lexical information and derive sentence- and discourse-level meaning (e.g., Language and Reading Research Consortium, [LARRC], 2015). Importantly, D and LC were originally characterized as independent processes (Hoover & Gough, 1990) that occurred sequentially (D before LC) and were both necessary, but neither singly sufficient, to engender reading (Gough & Tunmer, 1986). Most of the empirical work testing the original premise of the SVR has confirmed that much of the variance in reading comprehension can be accounted for by individual differences in D and LC (e.g., Catts, Hogan, & Adlof, 2005; de Jong & van der Leij, 2002; Hoover & Gough, 1990). However, we agree with the founders of the SVR that "there is much more to understand about reading than what is represented in the SVR" (Hoover & Tunmer, 2018, p. 311) and join other scholars (e.g., Catts, 2018; Cervetti et al., 2020; Compton-Lilly, Mitra, Guay, & Spence, 2020) who question the simplicity of the SVR for explaining reading comprehension and guiding instruction.

SVR: Its Simplicity Masks Complexity in Advancing the Science of Reading

Far from being simple, reading comprehension comprises a wide range of component skills and processes (Kendeou, van den Broek, White, & Lynch, 2009; Oakhill & Cain, 2012; Snow, 2002). Thus, one way that scholars have pushed on the original SVR framework is by investigating theoretical and empirical expansions of the SVR that include contributions of additional variables to reading comprehension beyond the original components (D and LC), such as background knowledge (Cromley & Azevedo, 2007; also see Kintsch, 2004), text characteristics (Francis, Kulesz, & Benoit, 2018), reading fluency (Tilstra, McMaster, van den Broek, Kendeou, & Rapp, 2008), and executive functions (EF), both domain-general (Locascio, Mahone, Eason, & Cutting, 2010) and reading-specific (Cartwright, Lee et al., 2020). Other expansions of the SVR have focused on unpacking the LC construct (LARRC, 2017; Kieffer, Petscher, Proctor, & Silverman, 2016; Kim & Pilcher, 2016), taking into account its multidimensionality and significance (e.g., Cervetti et al., 2020) by exploring the specific contributions of variables, such as inference making, perspective taking, and background knowledge to reading comprehension *through* LC (Kim 2017, 2020).

Another way in which a handful of scholars have recently pushed on the SVR is by examining directly the substantial shared variance between D and LC, suggesting that general cognitive variables may contribute to reading comprehension through the overlap between D and LC (e.g., Foorman & Petscher, 2018; Lonigan, Burgess, & Schatschneider, 2018). Recent work has confirmed the lack of independence between D and LC, finding, for example, that vocabulary contributes to both D and LC (Kim, 2020) and that LC contributes significant variance to reading comprehension through D, as well as independently (Cartwright, Lee et al., 2020; Tunmer & Chapman, 2012). As Lonigan et al. (2018) noted, both cognitive and linguistic factors may account for the shared variance between D and LC. Findings indicate multiple linguistic factors contribute to both D and LC, such as morphological knowledge (Apel, Wilson-Fowler, Brimo, & Perrin, 2012; Gottardo, Mirza, Koh, Ferreira, & Javier, 2018) and vocabulary (Kendeou, Savage, & van den Broek, 2009; Kim, 2020). However, none of these studies sought to directly examine the cognitive mechanisms – particularly how higher order processes such as EF skills – may undergird the shared variance between D and LC and contribute to reading comprehension through the shared variance of the two SVR key components. Our study addresses this gap.

Consistent with this work, in the current study, we use a multicomponent, latent construct for LC and extend prior empirical work by focusing on the contributions of multiple, latent EF skills – which are higher order cognitive skills that enable management of complex tasks (Diamond, 2013) to reading comprehension. EF skills are generally considered to be comprised of three core skills: cognitive flexibility, which involves the ability to switch flexibly between and among aspects of tasks like the semantic and phonological aspects of reading tasks; inhibition, which involves the ability to suppress responses, such as when readers suppress attention to distracting information in text; and working memory, which involves the ability to hold information in mind while transforming part of that information, as when readers construct a mental model of text meaning (e.g., Kintsch, 1988), and continually update it while reading. We examine EF skills' contributions to reading comprehension both independently and through the shared variance between D and LC. Importantly, given the efforts to elucidate the applicability of the SVR to EBs – children who are becoming bilingual as they speak a language other than English at home and receive instruction in English as school (García, Kleifgen, & Falchi, 2008) – in the last decade (e.g., Farnia & Geva, 2013; Gottardo, Javier, Farnia, Mak & Geva, 2014; Goodrich & Namkung, 2019) and the prevalence of this population in US schools, we include Spanish-speaking EBs, as well as EMs, in our sample.

EF Skills and Reading Comprehension

EF processes play an important role in coordinating the various components of reading tasks (Cartwright, Lee et al., 2020; Locascio et al., 2010; Nguyen, Pickren, Saha, & Cutting, 2020). EF skills are referred to as "a family of top-down mental processes" (Diamond, 2013, p. 136) that facilitate the coordination of complex, goal-directed tasks. Recent empirical work indicates that EF contribute to reading comprehension beyond the components of the SVR in EM (Georgiou & Das, 2018; Locascio et al., 2010) and EB students (Kieffer, Vukovic, & Berry, 2013; Taboada Barber et al., 2020). Drawing on recent reviews that have indicated that significantly more interaction exists between D and LC than was originally proposed by the founders of the SVR (see Cervetti et al., 2020 and Compton-Lilly et al., 2020 for reviews), we propose that the substantial overlap between D and LC (Foorman & Petscher, 2018; Lonigan, Burgess, & Schatschneider, 2018) provides a possible path through which EF skills may exert executive coordination of ongoing, simultaneous D and LC processes to facilitate reading comprehension – a hypothesis we test in the current study across EB and EM elementary school students.

SVR: Shared Variance between D and LC

The SVR was originally proposed to explain individual differences in reading, particularly for students with reading difficulties (Gough & Tunmer, 1986). The proposed independence of D and LC has led some to claim a clean categorization of reading disabilities such that they can be explained preponderantly by problems with D, LC, or both (e.g., Aaron, Joshi, & Williams, 1999; Elbert & Scott, 2016; Gough & Tunmer, 1986; Tunmer & Hoover, 1992). However, studies based on these SVR-guided classifications of reading difficulties have revealed that between 9 and 24% of learners with reading comprehension problems show such difficulties despite adequate D and LC skills (Aaron et al., 1999; Catts et al., 2005; Catts, Hogan & Fey, 2003; Hock et al., 2009). Further, consistent with our hypothesized role of EF skills in supporting coordination of D and LC processes in service of reading comprehension, Cutting and Scarborough (2012) found students with specific reading comprehension difficulties who had adequate D and LC skills but who were significantly lower on EF than their better performing peers – a pattern of reading development that cannot be explained by the dichotomous conception of the original SVR.

Recent work has demonstrated that D and LC are not independent, sequential processes as was originally proposed in the SVR because they share a good deal of common variance (i.e., they overlap, rather than being entirely dissociable or independent; e.g., Foorman & Petscher, 2018; Lonigan et al., 2018). Hypotheses have been advanced that there are cognitive-linguistic factors that underlie the common variance between D and LC, which may be malleable, although there is no clarity at this point what these are (e.g., Catts, 2018). For example, in a study of third- to fifth-grade EM students, Lonigan et al. (2018) found that between 41% and 69% of the variance accounted for in reading comprehension was shared between latent variables representing D and LC, suggesting other cognitive-linguistic factors may partially account for the robust prediction of reading comprehension from the components of the SVR. Additionally, Foorman and Petscher (2018) recently demonstrated that of the 60% of variance in first grade reading comprehension predicted by D and LC, 24% was unique to D, 17% was unique to LC, and 19% (i.e., close to a third of the variance predicted by D and LC) was shared between them.

The focus on the independence of the D and LC components has left fewer studies focusing on the substantial predictive *shared* variance between the two, an overlap that may reflect individual differences in general cognitive or linguistic abilities (Lonigan et al., 2018). In the current study we seek to add to the explanation of the shared variance between D and LC, and suggest that it is the shared variance between the two components of the SVR that can advance a more multifaceted and perhaps more precise, understanding of reading comprehension within the science of reading. We propose that the shared variance between D and LC can in be in part explained by the contribution of higher order cognitive skills such as executive function (EF) skills. In doing so we respond to calls for a more nuanced understanding of the SVR, under the premise that reading development "is not so simple" (LARRC, 2015, p. 167) and that the multidimensional nature of comprehension requires models that detail the cognitive processes operating within *and across* D and LC (Castles, Rastle, & Nation, 2018) and that, as such, can inform instruction and specific interventions (Catts, 2018).

The Current Study: The Role of EF Skills in Explaining Shared Variance in D and LC

We contend that one possible explanation for the overlap between D and LC in their prediction of reading comprehension is that the operation of these constructs may not be independent or sequential, as originally proposed. Rather than occurring after D has occurred, LC is likely to facilitate—or contribute to—decoding processes as well as act independently in facilitation of reading comprehension. Recent evidence supports this notion, as variables typically associated with LC, such as vocabulary, have been shown to be part of the same dimensions as D rather than LC constructs in 4- to 6-year-old children (Kendeou, Savage, & van den Broek, 2009; Kendeou, Papadopoulos, & Kotzapoulou, 2013) and as LC has contributed to reading comprehension directly, but also indirectly through word recognition (Tunmer & Chapman, 2012). Such interconnections between D and LC are necessary to support orthographic mapping between printed representations of words and their semantic and phonological features in the reader's mental lexicon (Perfetti & Stafura, 2014). This orthographic mapping is a claim supported by neurobiological evidence that indicates interaction between semantic and phonological processing regions in skilled readers (Yu et al. 2018).

We suggest that the shared variance between D and LC provides the pathway by which EF skills facilitate coordination of D and LC to support reading comprehension in both EMs and EBs. With EM students in elementary and secondary grades, Christopher et al. (2012) found that after controlling for cognitive predictors, the correlation between latent D and LC factors dropped significantly ($p < .01$) from .59 to .28, supporting the prediction that cognitive skills underlie shared variance between D and LC. With EBs a few studies have examined the roles of general cognitive predictors such as working memory (Farnia & Geva, 2013) and nonverbal reasoning (Babayiğit & Shapiro, 2020) in addition to D and varied measures of LC, with mixed findings, and not specifically addressing the shared variance between D and LC.

Wu et al. (2020) recently demonstrated that two of the three specific EF skills we currently examine (cognitive flexibility and inhibition) not only predicted growth in reading comprehension in EMs? from Grades 1 to 4, but that children with stronger EFs demonstrated faster rates of growth in reading comprehension. Within the last decade several studies have examined the role of EF components in reading comprehension both in EMs (e.g., Christopher et al., 2012) and EBs (Kieffer et al. (2013), but few have examined all three core EF skills simultaneously to consider their individual contributions to reading comprehension within its two core components as framed by the SVR.

Research Questions and Hypotheses

In this study we investigated the role that the three core EFs – cognitive flexibility, inhibition, and working memory – play in reading comprehension via the two key components of the SVR (D and LC), as well as via D and LC's shared variance in EMs and EBs in Grades 2-4. Three main research questions guided our study. Each research question is accompanied by specific hypotheses, guided by prior theory and empirical findings:

1. How much of the variance in reading comprehension is predicted by latent D and LC in total, uniquely for each (D and LC), and shared between them, in both in EM and EB students in Grades 2 to 4? Do the total, unique, and shared amounts of variance predicted in reading comprehension by the two SVR components vary by whether students are EMs or EBs (language group)? Through this question, we seek to replicate limited work on shared variance between D and LC (e.g., Foorman & Petscher, 2018; Lonigan et al., 2018) in EMs, extend it to EB students, and identify the putative path by which EF might influence reading comprehension.

   We hypothesized that the unique and shared amounts of variance would be similar across the two language groups, with shared variance between the two constructs being the largest portion based on prior findings with the same grade range (i.e., LRRC, 2015; Lonigan et al., 2018). We hypothesized, however, that amounts of unexplained variance will be larger for EBs than for EMs. We based this hypothesis on the multiple linguistic and cognitive skills (e.g., morphological awareness, syntactic awareness, inference making) and motivational processes that we did not account for in the current study that are important for both groups but that are likely to play a stronger role for students who tend to struggle with reading comprehension (Oakhill & Cain, 2012), as many EBs do, and for whom reading in English poses challenges that are compounded by their development of English proficiency at a given time point and over time (Kieffer, 2008).

2. If we find overlap between the D and LC constructs, what are the direct and indirect effects of D and LC on reading comprehension, which could help to explain the nature of the shared variance between them in EM and EB students in grades 2-4 and point to a potential mechanism of influence of EF on reading comprehension? That is, does LC contribute directly to D (based on prior evidence) and indirectly to reading comprehension through D? Do these effects vary by language group?

Based on prior evidence and theorization, we hypothesize that LC will have a direct strong effect on D, given that LC is likely to facilitate—or contribute to—decoding processes for both language groups, with no significant differences in the indirect effects on reading comprehension between the groups.

3. How do each of the three EF skills contribute to reading comprehension – directly or indirectly though LC or D, or through the shared (overlapping) variance between them – in Grades 2-4 in EMs and EBs? Do these effects vary by language group?

Building on prior findings (Taboada Barber et al., 2020) we posit that overall, all three EF skills will play strong roles (either directly or indirectly) in explaining reading comprehension in EBs and EMs alike, acting particularly through the shared variance between D and LC. However, given that in the current study we will identify the effects of each individual EF (as opposed to a composite of the three, Taboada Barber et al., 2020), we predict that cognitive flexibility and inhibition will have stronger indirect effects (through D and LC) on reading comprehension for EBs than for EMs. We base this hypothesis on prior empirical evidence that has described the role of inhibition for bilingual populations (Morales, Calvo, & Bialystok, 2013; Kroll, Bobb, & Hoshino, 2014) and work that identifies significant contributions of these EFs to reading comprehension in EB students (Kieffer et al., 2013), who may need to rely more heavily on EF skills to coordinate D and LC processes in English as their second language. That is, in EBs, both their languages appear always to be active, requiring continual attention to the contrasting features of the jointly activated languages, such that bilinguals have to continuously *attend* to both languages, "…creating the need for a general selection mechanism such as executive function to be recruited into language processing to avoid interference" (Bialystok, 2015, p.120). Specifically, we hypothesize that EBs will leverage cognitive flexibility and inhibition for reading comprehension in ways that their indirect effects on reading comprehension through D, LC, and their shared variance, will be stronger for EB students than their EM counterparts. Lastly, given the prominence and proximity that D and LC have to reading comprehension, we do not hypothesize any direct effects of EFs on reading comprehension when D and LC are in the model (for either language group); rather all effects of EFs will be mediated by LC, D, and particularly by the overlap between them.

Method

Participants

The participants were 727 students in Grades 2-4 attending three public elementary schools in a suburban mid-Atlantic school district. Of these students, 425 were designated EBs because they were currently eligible for English for Speakers of Other Languages (ESOL) instruction (78% of EBs) or had been eligible for ESOL any time since entering the school/district. Additionally, 97% percent of 401 EBs who were asked about the language(s) they spoke at home reported speaking a non-English language, with 92% specifically reporting that they spoke Spanish. The greatest proportion of EBs (44%) reported *mostly* speaking their non-English language at home, while 21% reported *solely* doing so. The remainder reported speaking both English and another language equally at home (17%) or not being sure what language was predominant at home (17%). The remaining 302 students, all of whom were ineligible for ESOL and reported speaking only English, were designated EMs.

Table 1 provides detailed demographic information. As indicated there, a large majority of students in both language groups (73% of EMs and 90% of EBs) were eligible for Free and Reduced Price Meals (FARMS), and, similarly school-level poverty was high, based on both school FARMS rates (61-92%) and our general knowledge of the school communities. Given that this was the only socioeconomic data available to us and that school-level poverty may be a stronger indicator of reading achievement than individual SES (Kieffer, 2008), we did not employ FARMs as a control in analyses.

In all schools, students received daily phonics instruction and reading comprehension instruction emphasizing reading strategies three days a week. Three to five times per week students participated in guided reading lessons, using the Fountas and Pinnell system of A-Z reading levels. Children eligible for ESOL instruction received it in 15-20 minute pullout sessions three to four times per week. These lessons focused on oral English instruction.

Measures and Procedure

Students were assessed by a team of trained researchers in the fall of 2016. All assessments took place in quiet locations in the schools over two testing periods (one individual and one group) for approximately 60 minutes each period. One measure (Fountas and Pinnell word reading accuracy) was obtained from school district records. On the first day students completed all individual measures (one reading comprehension, one decoding, two linguistic comprehension, and three EF assessments) and a demographic survey on language use. On the second day, the Gates-MacGinitie reading comprehension test (group) was administered. EBs had sufficient knowledge of English to understand all task instructions, which were in English. Assessors completed two fidelity checks prior to data collection. Institutional Review Board approval, parental consent, and teacher consent were obtained prior to data collection. All activities were carried out in accord with APA ethical guidelines. Table 2 describes the measures administered.

Data Analytic Approach

Research questions were addressed drawing results from three multigroup structural equation models, allowing for results within and between EM and EB groups. For each of these models, robust full information maximum likelihood estimation was used with Mplus 8.4 (Muthén & Muthén, 2019) to accommodate potential nonnormality and missingness. The first multigroup model had latent D and LC as covarying predictors of latent reading comprehension, controlling for grade level using two group code dummy variables. Measured indicators for these latent variables, and those of latent variables in subsequent models, appear in Table 2; quality of all constructs was assessed using Coefficient *H* (Hancock & Mueller, 2001), which has a recommended threshold of .70 (see Table 2 for obtained values, by language group). Loadings were constrained equal across groups in all models (with the lone exception of the Gates indicator of reading comprehension); differences between corresponding direct, indirect, and total effects across EM and EB groups were assessed by creating additional model parameters representing each cross-group difference and constructing 95% bias-corrected bootstrap confidence intervals for all parameters based on 5000 replications. The primary purpose of this first model was to decompose contributions of D and LC to reading comprehension into their unique and shared components (see, e.g., Foorman & Petscher, 2018; Lonigan et al., 2018) for the EM and EB language groups. The second multigroup model was a variation on the first model, still with direct paths from D and LC to reading comprehension but also with a direct path from LC to D rather than covariance (and still controlling for grade as before). Thus, in this model LC had the potential to affect reading comprehension directly as well as indirectly as mediated by D. Finally, the third multigroup model augmented the second by introducing three covarying EFs (cognitive flexibility, inhibition, and working memory) with direct effects to LC, D, and reading comprehension (still controlling for grade), thus allowing for a comprehensive assessment of EFs' direct effects, as well as indirect and total effects on reading comprehension as mediated by D and LC.

Results

Descriptive Statistics

In Table 3, we present the means, standard deviations, and correlations for all indicator variables used in the SEM analyses, scaled as specified in Table 2 (due to dramatically different metrics of some variables within the same model, some were divided by a constant to facilitate model convergence, as is common practice and which in no way affects model fit or parameter significance). The EMs performed better than the EBs on all reading comprehension (both), D, and LC indicators. However, the two groups performed equally well on all EF indicators, using the Bonferroni-corrected *p* value of .004 ($p = .05/13$ comparisons).

Research Question 1: Decomposition of Variance

The first model had acceptable overall fit of the multigroup model: χ^2 (30 df) = 73.76, $p < .001$; RMSEA = 0.063 (90% CI: 0.045, 0.082); CFI = 0.983; TLI = 0.970. In both language groups, after controlling for grade, the degree of correlation between the D and LC factors was very strong, positive, and statistically significant ($r = .603$ for EMs and $r = .635$ for EBs, *p*s < .001), suggesting a substantial degree of overlap between these two latent constructs. For EMs, latent D and LC constructs accounted for 88.2% of the variance in latent reading comprehension. Of note, only 5.4% of that variance was predicted uniquely by LC, 33.4% was predicted uniquely by D, and the relative majority of variance predicted in reading comprehension for EMs, 48.4%, was common to D and LC, consistent with amounts of shared variance found in prior work (Foorman & Petscher, 2018; Lonigan et al., 2018). Only 11.8% of the variance was left unexplained in EM in the grades in this study (2-4). Similarly, for EBs, the total variance accounted in reading comprehension by latent D and LC constructs was 73.0%. Only 5.8% of that variance was predicted uniquely by LC, 31.4% was predicted uniquely by D. Additionally, and again similar to EMs, the relative majority of variance predicted in reading comprehension for EBs, 35.8%, was shared by D and LC, showing that D and LC are not independent, as the original SVR proposed. Different from the smaller amount of unexplained variance in EMs, 27.0% of the variance was left unexplained in EBs in grades 2-4. See Figure 1.

Research Question 2: Direct and Indirect Effects of D and LC on Reading Comprehension

In this question we aimed to answer *how* the shared and individual variance between D and LC (research question 1) contributes to reading comprehension. As described above, we compared direct and indirect effects of latent D and LC on reading comprehension for EBs and EMs. See Figure 2 for a depiction of key elements of this model, which retains the structure of the SVR with direct contributions of D and LC to reading comprehension but incorporates a path from LC to D to account for shared variance between these constructs and the known influences of LC on D that have emerged in prior work. The overall fit of this multigroup model was identical to that of the first model, given that they differ only in the nature of the relation between D and LC. As predicted, significant direct paths from latent D and LC to reading comprehension emerged for both the EM and EB groups, consistent with predictions of the SVR. Additionally, the novel path from LC to D to reading comprehension was significant for both language groups (Figure 2; also see Table 4) and not significantly different across the groups.

Research Question 3: Direct and Indirect Effects of EF Skills on D, LC, and Reading Comprehension

Research question 3 addressed the impact of each of the three EFs (cognitive flexibility, inhibition, and working memory) to each of the components of the SVR, D and LC, and to reading comprehension. See Figure 3 for a depiction of our proposed model, which retains the structure of the SVR with direct contributions of D and LC to reading comprehension, retains the new path from LC to D (from Research Question 2), and adds latent constructs for two of the core EF skills (cognitive flexibility and inhibition) and a manifest measure of working memory. Data-model fit for the multigroup model was excellent: χ^2 (130 df) = 145.998, p = .160; RMSEA = 0.018 (90% CI: 0.000, 0.032); CFI = 0.996; TLI = 0.993. We found significant direct effects of all three EFs across language groups: cognitive flexibility contributed directly to LC for both language groups, with twice the effect for EB students; working memory contributed directly to

D for EBs and to LC for both language groups; inhibition contributed directly to D for both language groups (see Figure 3 and Table 5).

In addition to direct effects, EFs exerted multiple indirect effects on reading comprehension through D and LC. Cognitive flexibility contributed to reading comprehension indirectly, through LC for both language groups. Inhibition contributed indirectly to reading comprehension through D across language groups. Working memory's indirect influences differed across language groups, however, making significant indirect contributions to reading comprehension through D and LC only for EBs (see Table 5). Both cognitive flexibility and working memory made significant indirect contributions to reading comprehension through LC's influence on D, suggesting EF skills may help students coordinate the semantic and graphophonological aspects of text in support of reading comprehension. These indirect influences of cognitive flexibility and working memory on reading comprehension through LC's influence on D held across language groups (see Table 5). These indirect effects are important as they tap into the shared variance between D and LC central to our hypothesis.

Discussion

In this study we aimed to contribute to the science of reading by forwarding a more nuanced view of key components of the SVR, a framework that has guided a significant amount of empirical work and influenced reading instruction and policy in English-speaking countries within the last three and a half decades (e.g., McGinty & Bevilacqua, 2016; Rose, 2006). In agreement with prior work (e.g., Lonigan et al., 2018) we provided evidence to support the importance of the shared variance between the two key components of reading comprehension in the SVR, D, and LC. We did so by using latent variables within an SEM framework that allowed us to gradually explore the role that EF skills had in the influence that LC exerted on D. The

SVR was originally intended to make a clear case that D was essential for reading comprehension (Gough & Tunmer, 1986), and it has done so remarkably well over the last three decades, a fact which may explain its popularity as a guiding framework for the contemporary science of reading movement, which emphasizes research evidence as the basis for effective reading instruction. However, science continually evolves in order to refine understanding of phenomena as new discoveries are made and multiple “paradigms” are considered (Kuhn, 1962). A substantial body of emerging scientific findings, including our own, suggests the SVR’s elegant simplicity may mask contributions to reading comprehension that could – and should – inform research, practice and, ultimately, the science of reading (see Cervetti et al., 2020; Snowling & Hulme, 2012, for reviews). In particular, the original independent, two-factor SVR model, and its typical implementation in practice, disallows commonalities among D and LC and, occasionally, neglects scientific findings that LC contributes directly to D – and to reading comprehension through D – partially explaining the substantial shared variance between these constructs (e.g., Cartwright, Lee et al., 2020; Tunmer & Chapman, 2012). Our findings suggest that LC facilitates word reading processes, in contrast to the assumption, based on the original SVR, that decoding processes occur first, after which readers apply their LC skills to understand what they have decoded (Gough & Tunmer, 1986). In addition, our findings support the idea that general cognitive-linguistic skills, such as EF skills, undergird the shared variance between D and LC. This builds on prior work, demonstrating that EFs contributed to reading comprehension directly and indirectly (through higher order strategic skills) for both EBs and EMs in Grades 1-4, but with LC controlled for, instead of allowed to explain the role of EFs in reading comprehension (Taboada Barber et al., 2020). In unpacking the shared variance between D and

LC, we expand the SVR framework and lead to more nuanced understandings of the multifaceted nature of reading comprehension.

The Role of Shared Variance in Reading Comprehension

Our first question asked how partitioning of variance -- total, unique, shared, and unexplained -- of D and LC explained reading comprehension in EBs and EMs in Grades 2 to 4. In agreement with recent findings and analyses (e.g., Lonigan et al., 2018; Foorman & Petscher, 2018), and confirming our hypotheses, we found that the largest amount of variance predicted in reading comprehension by D and LC was shared between these constructs. We agree with other scholars that the substantial overlap between D and LC in the prediction of reading comprehension suggests other cognitive-linguistic variables may be contributing to reading comprehension via the overlapping portions of D and LC (i.e., the non-unique portions of D and LC). One possibility is that the shared influence of D and LC on reading comprehension may be due to LC's direct facilitation of D, as has been found in prior work (e.g., Cartwright, Lee et al., 2020; Tunmer & Chapman, 2012). We addressed this possibility in our second research question. A second possibility is that general cognitive or linguistic skills, such as EF skills, may facilitate reading comprehension through the overlapping portions of D and LC, which we addressed with our third research question. Also, in agreement with our hypotheses we found that there was a substantial amount of variance left unexplained, and that this amount was twice as large for EBs, which agrees with the idea that there are multiple processes that may be impacting the reading of these students in English differently than for their EM peers. For example, in comparing the prediction of reading comprehension between EBs and EM in Grades 2 to 5, Geva and Farnia (2012) found that syntactic skills, vocabulary breadth, and specific measures of listening comprehension emerged as additional language proficiency components in predicting reading comprehension in EBs but not EMs.

LC Facilitates D Equally for EMs and EBs in the Elementary School Years

In our second research question we sought to explore the path that could explain the shared variance between D and LC in both language groups, by constraining the directionality of this relation from LC to D. We found that, as hypothesized, LC had a direct strong effect on D, supporting the idea that LC facilitates D for both language groups. The facilitation of LC on D is likely due to what Ehri (2005a; 2005b; 2014) called orthographic mapping: the process or skill by which readers form connections from the meanings (i.e., entries in their oral lexicons) to the spellings and pronunciations of specific words by applying knowledge of the alphabetic writing system. These mapping connections serve as the “glue” between word spellings to their pronunciations and meanings in memory (Ehri, 2014). Readers differ in the connections that are activated to bond words in memory. Perfetti (2007) proposed the idea of lexical quality to represent variation in the representation of words that are formed in memory to support reading and spelling. Having high lexical quality for a word includes knowing various meanings for the same word, as well as possessing complete spellings that are fully connected to their pronunciations (Ehri, 2015). Perfetti and Stafura (2014) proposed that coordination of these multifaceted lexical entries is facilitated by executive processing (i.e., EFs).

Finding that LC had a strong direct effect on D speaks of the applicability of the basic structure of the SVR to both EMs and EBs (Hoover & Gough, 1990; Verhoeven & van Leeuwe, 2012). It builds, however, on prior findings, by providing evidence for the role that LC may have in the facilitation of reading processes for all readers – but especially EBs. That is, numerous studies have supported the key role that oral language development, particularly vocabulary, plays in the comprehension of EBs (e.g., Kieffer, 2012; Verhoeven, Voeten, & Vermeer, 2019); less is known, however, about the role that LC plays in the concurrent and later reading comprehension of EBs. The current findings suggest that greater emphasis should be placed on LC instruction in the early grades.

How EF Skills May Contribute to Reading Comprehension

Our third research question added the inclusion of the three core EFs as potential mechanisms for the explanation of the indirect strong effect of LC through D on reading comprehension. In agreement with prior work (Taboada Barber et al., 2020) and our hypothesis, we found that direct and indirect effects of EF skills on and through D and LC to reading comprehension were significant across both language groups, with some key differences between EBs and EM on specific EFs. In particular, cognitive flexibility had a direct effect on LC and also an indirect effect through LC on reading comprehension for both EMs and EBs, but the size of the direct effect on LC was twice as large for EBs as for EMs. Notably, EBs did not differ from their EM peers across all three EFs. Rather, they differed in how much EF facilitated LC. Among the three EFs, cognitive flexibility may be especially important for EB students because it represents the ability to actively switch between components of a task (e.g., graphophonological and meaning components of words during reading), and there is evidence that bilinguals must actively be shifting attention between English and their home language. In particular, the explanation that bilinguals may be stronger on specific EF skills than monolinguals derives from evidence showing that both languages are always active in bilinguals, so EFs are recruited by the language processing system and, thereby, this system becomes reorganized, fortified, or both (Bialystok, 2015; Kroll et al., 2014). Thus, the theoretical underpinning of fortified EFs in bilinguals supports the view that “bilingualism *trains* executive function through its constant recruitment for language selection" (Bialystok, 2015, p. 118). At the same time, the joint activation of two languages likely makes linguistic processing more effortful for bilinguals than for monolinguals, which explains some of the costs on language tasks that bilinguals have (Bialystok, Craik, & Luk, 2012). Cognitive flexibility is one of those EF skills that requires effortful, consistent shifts of attention. In this study, cognitive flexibility was measured by requiring students to perform a task that required switching attention between *multiple elements* in a sorting task, enlisting children's ability to shift effectively between these dimensions. Clearly, cognitive flexibility rests on the shifting of attention that bilinguals in adult and child samples in other settings have done well. Within the area of relations to reading, our findings for the alleged advantage of EBs on cognitive flexibility is supported by evidence of significant direct contributions of inhibition and shifting (cognitive flexibility) to the reading comprehension of EBs (Kieffer et al., 2013).

Inhibition, however, revealed strong direct (on D) and indirect effects through D on reading comprehension, for both language groups, providing a more direct explanation of the potential contribution of this particular EF to reading comprehension via D. Both direct and indirect effects of inhibition through D make sense in light of evidence and explanations that posit that inhibitory processes such as the suppression of irrelevant word-level information (e.g., Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001) are particularly important for word recognition (Conrad, Carreiras, Tamm, & Jacobs, 2009; Ziegler & Muneaux, 2007) and may explain why children with word reading difficulties display corresponding deficits in inhibition (e.g., Booth, Boyle, & Kelly, 2014). We build on this body of work by showing that inhibition appears to work in similar ways for EBs and EMs.

Lastly, working memory had significant direct effects on LC for both language groups. However, working memory had significant direct effects on D and significant indirect effects on reading comprehension through D and LC for EBs only. The stronger effects of working memory on D for EBs may be portraying the leveraging of working memory skills needed for EBs' more effortful decoding. Although evidence shows that EBs tend to perform comparably to their EM peers or to national norms in word reading skills (Mancilla-Martinez & Lesaux, 2010; Nakamoto, Lindsey, & Manis, 2007), by Grade 3 (Lesaux, Kieffer, Faller, & Kelley, 2010; Mancilla-Martinez & Lesaux, 2011) D still appears to require more effort for EBs than for EMs – possibly, due to their weaker LC skills – but as evinced by these effects, also through the role of working memory. This pattern agrees with evidence showing that working memory skills support decoding processes for individuals with decoding weaknesses (Hamilton, Freed, & Long, 2016).

Limitations

We would like to highlight at least two limitations to our current study. The first regards measurement: We acknowledge that D, LC, and the three core EFs we used comprise a vast array of subskills and that, as such, only capture partial dimensions of the actual construct to be measured. Particularly, we would encourage future research to consider measures of EFs that rely more on control of attention that have been used with bilinguals (e.g., Bialystok, 2015) and that rely less on language skills than the ones we used in the current study. Related to this limitation is the fact that there was some variability in English proficiency in our EB sample, as it included students with sufficient English to understand the study tasks to those who have developed sufficient English to exit ESOL services. More specifically, 78% of the EBs were currently eligible for ESOL instruction, while 19% had been released from ESOL in the last 2 years, and 3% had been released more than 2 years ago. This variability is compounded by our limited knowledge on the EBs' proficiency in their first language (mostly Spanish), thus leaving us with fewer implications of these findings for children who vary within the bilingualism spectrum.

Practical Implications

Our findings—and those of others (e.g., Tunmer & Chapman, 2012)—indicate LC is necessary for skilled D, and that LC impacts reading comprehension through its effect on D. More work needs to unpack the instructional implications of LC's contribution to D, so that decoding instruction retains its essential focus on graphophonic knowledge and orthographic mapping, while leveraging the potentially facilitative influence of LC on D that may be at the heart of the strong connections that develop between orthographic, phonological, and lexical-semantic information for skilled decoders (Ehri, 2014; Perfetti & Stafura, 2014). Additionally, EF skills may be important precursors for supporting the development of both D and LC, as well as development of the ability to flexibly coordinate these simultaneous processes to support reading comprehension. EF interventions have been shown to improve reading comprehension for EMs (e.g., Cartwright, Bock et al., 2020; Dahlin, 2011; García-Madruga et al., 2013; Johann & Karbach, 2019), but the mechanism of those effects (i.e., whether they facilitate reading comprehension through D, LC, or both) has not been investigated. Further, we know of no studies that have examined EF interventions for EB students, which should be explored in future work.

The malleability of EFs, and their direct influence on reading comprehension, is documented by evidence of EF interventions that improve reading comprehension directly (e.g., Dahlin, 2011; Johann & Karbach, 2019). This intervention evidence provides additional support for the influence of the two EFs – cognitive flexibility and working memory – that we found influence reading comprehension through the novel, indirect path from LC through D to reading comprehension. These studies, however, have focused on first-language speakers. For example, studies have demonstrated significant effects of working memory interventions for 3rd to 5th grade EM students with learning difficulties (Dahlin, 2011), typically developing EMs (Henry, Messer, & Nash, 2014), German speakers (Karbach, Strobach, & Schubert, 2015), and Swiss-German speakers (Loosli, Buschkuehl, Perrig, & Jaeggi, 2012) of the same age range. Facilitative effects of working memory training on reading comprehension were more pronounced when the intervention was presented in a game-like context, possibly due to effects on students' motivation and engagement (Johann & Karbach, 2019). Positive impacts of motivation and engagement within EF interventions designed to improve reading comprehension should be explored in future work.

The malleability of EFs has also been demonstrated in studies of cognitive flexibility interventions. For example, a reading-specific cognitive flexibility intervention, focusing on the coordination of graphophonological and semantic aspects of print, improved reading comprehension for 2nd to 4th grade typically developing EM students (Cartwright, 2002) and 2nd to 5th grade teacher-identified struggling readers (Cartwright, Bock et al., 2020). In addition to improving reading comprehension, the cognitive flexibility intervention in these studies also improved students' ability to flexibly shift attention between the graphophonological and semantic aspects of print, emphasizing the importance of readers' abilities to coordinate elements of D and LC in service of reading comprehension, which contributes directly and indirectly to reading comprehension in adults beyond contributions of other EFs, D, and LC (Cartwright, Lee et al., 2020). Effects of EF interventions such as these should be explored in EB students. We note, however, that not all EF interventions are effective for improving reading outcomes (see Jacob & Parkinson, 2015, for a review). Domain-specific interventions – those tied to the specific demands of literacy tasks – are more effective than domain-general EF interventions (Melby-Lervåg & Hulme, 2013; Peng & Goodrich, 2020), a point that should be explored in future work with EB students.

Theoretical Implications

In agreement with prior work (e.g., LARRC, 2015) this study supports establishing a more comprehensive view of critical components of reading in the elementary years, especially when language minority populations are considered. That is, our findings indicate that the SVR is too simple, given that the unique contributions of D and LC to reading comprehension were relatively small in comparison to the substantial overlapping contributions to reading comprehension that were shared between D and LC, across EMs and EBs. This common variance suggests elements outside D and LC may contribute to both skills, and to reading comprehension through them – like EFs. Future work should examine additional factors to continue to unpack influences on reading comprehension attributable to common variance between D and LC. Additionally, more work is needed to better understand ways that LC facilitates D, which may help to further explain common variance between them. Understanding these nuances will move the science of reading forward, beyond dichotomous applications of the components of the SVR, to better assess reading comprehension difficulties and foster success for all students, especially emergent bilinguals.

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Table 1

Sample Demographics

	Full sample (%) (*n* = 727)	English Speakers (%) (*n* = 302)	Dual Language Learners (%) (*n* = 425)
Grade			
Second	32.5	28.8	35.1
Third	35.8	38.4	33.9
Fourth	31.8	32.8	31.1
FARMs			
Yes	83.2	73.0	90.1
No	16.8	27.0	9.9
Gender			
Female	48.1	53.2	44.7
Male	51.9	46.8	55.3
Ethnicity/race			
Hispanic	61.7	13.3	94.2
Black	30.2	72.3	1.9
White	4.5	9.0	1.4
Multi-racial	1.4	3.6	0.0
Native Hawaiian/ Pacific Islander	0.1	0.0	0.2
Asian	2.0	1.8	2.2

Note. FARMs indicates proportions of students eligible for free and reduced price meals.

Table 2

Assessment Information

Construct	Assessment	Source	What students are asked to do	Indicators used in current analyses	Task reliability	Construct reliability (Coefficient *H* or Cronbach's alpha[b])
Reading comprehension	GM reading comprehension (Form S, Levels 2/3/4[a])	MacGinitie et al., 2000; Maria & Hughes, 2008	Silently read narrative/expository passages of 3-15 sentences each; Answer multiple choice questions following each passage, with passage in view	Total correct converted to publisher's standardized scale (Extended Scale Scores [ESSs])	From manual: .92-93 K-R 20; .86-.87 alternate form, levels 2-4	ES: .84 DLL: .86
	WJ-IV passage comprehension (Form C)	Schrank et al., 2014; McGrew et al., 2014	Match picture symbols with actual pictures; identify pictures that correspond to 1-3 written words; Silently read sentences missing a word and supply that word based on syntactic and semantic clues	Total correct converted to publisher's standardized scale (*W* scores)	From manual: .89-.98 split-half, ages 7-10	
Decoding	WJ-IV word identification	Schrank et al., 2014; McGrew et al., 2014	Read list of letters and words aloud	Total correct converted to publisher's standardized scale (*W* scores)	From manual: .94-.98 split-half, ages 6-10	ES: .87 DLL: .93

	FPBAS reading accuracy	Fountas & Pinnell, 2007	Read aloud text passage at student's instructional level	Percent of words read accurately	From manual: .97, test-retest for fiction & non-fiction From other studies: .86, test-retest fall to spring, grades 2-3 (Klingbeil et al., 2015)	
Linguistic comprehension	WJ-IV picture vocabulary	Schrank et al., 2014	Identify pictures of objects using single words	Total correct converted to publisher's standardized scale (*W* scores)	From manual: .77-.78 split-half, ages 6-10	ES: .65 DLL: .82
	WJ-IV oral comprehension	Schrank et al., 2014	Listen to sentences missing the final word and supply that word based on syntactic and semantic clues	Total correct converted to publisher's standardized scale (*W* scores)	From manual: .78-.83 split-half, ages 6-10	
Executive function – cognitive flexibility	Cognitive flexibility	Cartwright et al., 2010	Sort two sets of 12 pictures of objects based on both color (e.g., red or yellow) and type (e.g., fruit or flower) into a 2 x 2 matrix; Sort two sets of 12 printed words by initial phoneme (e.g., /b/ or /t/), and word meaning (e.g., vehicle or animal)	Scores for the 4 sets (number of points earned divided seconds taken to complete sort, multiplied by 100; 3 pts were possible per set, 1 for a correct sort & 2 for a correct explanation)	From original source: .86-90 Cronbach's alpha, grades 1-2 From other study with DLLs: .60-.77 (Taboada Barber et al., grades 1-4)	ES: .67 DLL: .77

Executive function – inhibition	NEPSY II inhibition	Korkman, Kirk, & Kemp, 2007	Name two series of 40 objects each (i.e., circles and squares/up and down arrows) as quickly as possible, and then provide the opposite names for a series of the same objects (e.g., “square” for circle, “up” for down)	Scores for the 2 series of opposite trials (number correct divided by seconds taken to complete trial, multiplied by 100)	From manual: .72 Cronbach’s alpha, ages 7-12 From study with DLLs: .71-85 Cronabch’s alpha, grades 1-4 (Taboada Baber et al., 2020)	ES: .72 DLL: .71
Executive function – working memory	TOMAL-2 letters backward	Reynolds & Voress, 2007	Repeat lists of 2-16 letters backward immediately after hearing them read aloud	Number of letters recalled in correct order across all lists	From manual: .67 test-retest, ages 5-18	ES: .71 DLL: .74

Note. GM = Gates-MacGinitie Reading Tests, fourth edition. WJ-IV = Woodcock-Johnson IV Tests of Achievement, fourth edition. FPBAS = Fountas and Pinnell Benchmark Reading System 2. NEPSY II = A Developmental NEuroPSYchological Assessment, second edition. TOMAL-2 = Test of Memory and Learning, second edition. [a] Participants completed the level corresponding to their grade in school. [b] For current construct reliability, coefficient *H* (Hancock & Mueller, 2001) is reported for all constructs represented with latent variables. For working memory, the one construct which was manifest rather than latent, Cronbach’s alpha values are reported.

Table 3

Bivariate Correlations and Descriptive Statistics for Each Indicator by Language Group (ESs or DLLs)

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. GM read. comp.	—	.73	.72	.47	.41	.54	.25	.28	.15	.45	.36	.34	.36
2. WJ-IV pass. comp.	.73	—	.78	.55	.38	.56	.22	.28	.17	.40	.34	.35	.39
3. WJ-IV word id.	.75	.85	—	.62	.40	.47	.20	.17	.17	.42	.38	.33	.35
4. FPBAS read. acc.	.54	.58	.63	—	.20	.34	.09	.10	.13	.27	.34	.28	.23
5. WJ-IV pic. voc.	.50	.65	.57	.38	—	.46	.10	.16	.11	.30	.16	.21	.23
6. WJ-IV oral comp.	.50	.63	.54	.32	.69	—	.20	.21	.12	.34	.28	.24	.29
7. Cog. flex. – set 1	.30	.28	.24	.18	.30	.33	—	.41	.08	.34	.21	.27	.10
8. Cog. flex. – set 2	.27	.21	.19	.14	.16	.23	.43	—	.13	.35	.25	.25	.15
9. Cog. flex. – set 3	.44	.41	.39	.29	.39	.41	.35	.28	—	.24	.17	.07	.06
10. Cog. flex. – set 4	.45	.43	.38	.27	.42	.41	.38	.25	.60	—	.34	.41	.26
11. NEPSY II inhibition – series 1	.39	.27	.32	.23	.20	.22	.16	.16	.25	.25	—	.57	.31
12. NEPSY II inhibition – series 2	.34	.28	.38	.21	.17	.18	.17	.14	.22	.20	.55	—	-.34

13. TOMAL-2 letters backward	.38	.43	.41	.31	.30	.31	.16	.12	.25	.22	.30	.29	—
ESs													
M	438.59	471.62	476.18	96.21	482.10	486.30	5.94	6.60	4.17	3.68	94.48	80.55	11.79
SD	47.56	19.62	28.24	2.77	10.30	12.40	6.07	4.97	11.18	3.74	27.72	45.66	4.66
DLLs													
M	419.29	454.75	457.56	94.57	465.72	472.40	4.79	6.21	2.81	2.88	91.80	76.50	10.94
SD	42.16	22.43	32.81	4.45	13.01	16.69	4.45	6.86	3.22	3.46	27.49	23.77	4.86

Note. Values for DLLs appear below the diagonal; values for ESs appear above the diagonal. Pairwise deletion was employed. GM read. comp. = Gates-MacGinitie reading comprehension. WJ-IV pass. comp. = Fountas and Pinnell Benchmark Reading System 2 reading accuracy. Woodcock-Johnson IV passage comprehension. WJ-IV word id. = Woodcock-Johnson IV word identification. FPBAS read. acc. = WJ-IV pic. voc. = Woodcock-Johnson IV picture vocabulary. WJ-IV oral comp. = Woodcock-Johnson IV oral comprehension. Cog. Flex. = cognitive flexibility.

Table 4

Unstandardized Direct Effects, Indirect Effects, and Total Effects, with Bootstrapped Bias-Corrected 95% Confidence Intervals in the Structural Model Predicting Reading Comprehension from Decoding and Linguistic Comprehension, Controlling for Grade Level

		Direct effect		Indirect effect through D		Total effect	
Group	Path	Est.	95% CI	Est.	95% CI	Est.	95% CI
ES							
	LC → D	**.331**	**[.225, .439]**			**.331**	**[.225, .439]**
	LC → RC	**.367**	**[.135, .598]**	**.529**	**[.355, .756]**	**.897**	**[.698, 1.123]**
	D → RC	**1.598**	**[1.222, 2.021]**			**1.598**	**[1.222, 2.021]**
DLL							
	LC → D	**.332**	**[.266, .414]**			**.332**	**[.266, .414]**
	LC → RC	**.332**	**[.152, .488]**	**.498**	**[.375, .666]**	**.831**	**[.708, .961]**
	D → RC	**1.500**	**[1.127, 2.001]**			**1.500**	**[1.127, 2.001]**

Note. Bold type indicates confidence intervals that do not include zero and thus are significant.
CF = cognitive flexibility. D = decoding. RC = reading comprehension.

Table 5

Unstandardized Direct Effects, Indirect Effects, and Total Effects, with Bootstrapped Bias-Corrected 95% Confidence Intervals in the Structural Model Predicting Reading Comprehension from Decoding, Linguistic Comprehension, and Three Executive Functions, Controlling for Grade Level

		Direct effect		Indirect effect through LC		Indirect effect through D		Indirect effect through LC and D		Total effect	
Group	Path	Est.	95% CI	Est.	95% CI	Est.	95% CI	Est.	95% CI	Est.	95% CI
ES											
	CF → LC	**.121**	**[.068, .412]**							**.121**	**[.068, .412]**
	CF → D	.008	[-.112, .040]								
	CF → RC	.044	[-.020, .040]	**.042**	**[.013, .221]**	.012	[-.164, .061]	**.064**	**[.030, .307]**	**.161**	**[.097, .381]**
	WM → LC	**.024**	**[.005, .042]**							**.024**	**[.005, .042]**
	WM → D	.006	[-.003, .018]								
	WM → RC	.011	[-.007, .028]	.008	[.000, .022]	.010	[-.004, .031]	**.013**	**[.003, .028]**	**.041**	**[.016, .069]**
	IN → LC	-.042	[-.579, .103]							-.042	[-.579, .103]
	IN → D	**.114**	**[.020, .303]**								
	IN → RC	-.090	[-.317, .096]	-.014	[-.0614, .030]	**.174**	**[.034, .518]**	-.022	[-.441, .049]	.048	[-.393, .247]
	LC → D	**.345**	**[.191, .553]**							**.345**	**[.191, .553]**
	LC → RC	.343	[-.030, .718]			**.527**	**[.315, .941]**			**.870**	**[.541, 1.314]**
	D → RC	**1.530**	**[1.070, 2.130]**							**1.530**	**[1.070, 2.130]**
DLL											
	CF → LC	**.243**	**[.184, .317]**							**.243**	**[.184, .317]**
	CF → D	-.004	[-.034, .027]								

CF → RC	.022	[-.020, .065]	**.074**	**[.029, .124]**	-.006 [-.050, .041]		**.101**	**[.065, .156]**	**.192**	**[.135, .258]**
WM → LC	**.036**	**[.015, .060]**							**.036**	**[.015, .060]**
WM → D	**.012**	**[.002, .023]**								
WM → RC	.009	[-.005, .024]	**.011**	**[.004, .023]**	**.018**	**[.003, .035]**	**.015**	**[.006, .029]**	**.052**	**[.033, .076]**
IN → LC	-.030	[-.206, .136]							-.030	[-.206, .136]
IN → D	**.087**	**[.014, .175]**								
IN → RC	-.035	[-.153, .063]	-.009	[-.074, .039]	**.127**	**[.022, .297]**	-.013	[-.096, .054]	.070	[-.086, .222]
LC → D	**.287**	**[.213, .378]**							**.287**	**[.213, .378]**
LC → RC	**.304**	**[.115, .463]**			**.416**	**[.291, .603]**			**.720**	**[.562, .881]**
D → RC	**1.452**	**[1.060, 2.054]**							**1.452**	**[1.060, 2.054]**

Note. Bold type indicates confidence intervals that do not include zero and thus are significant.
CF = cognitive flexibility. WM = working memory. IN = inhibition. LC = linguistic comprehension. D = decoding. RC = reading comprehension.

Figure 1.a.

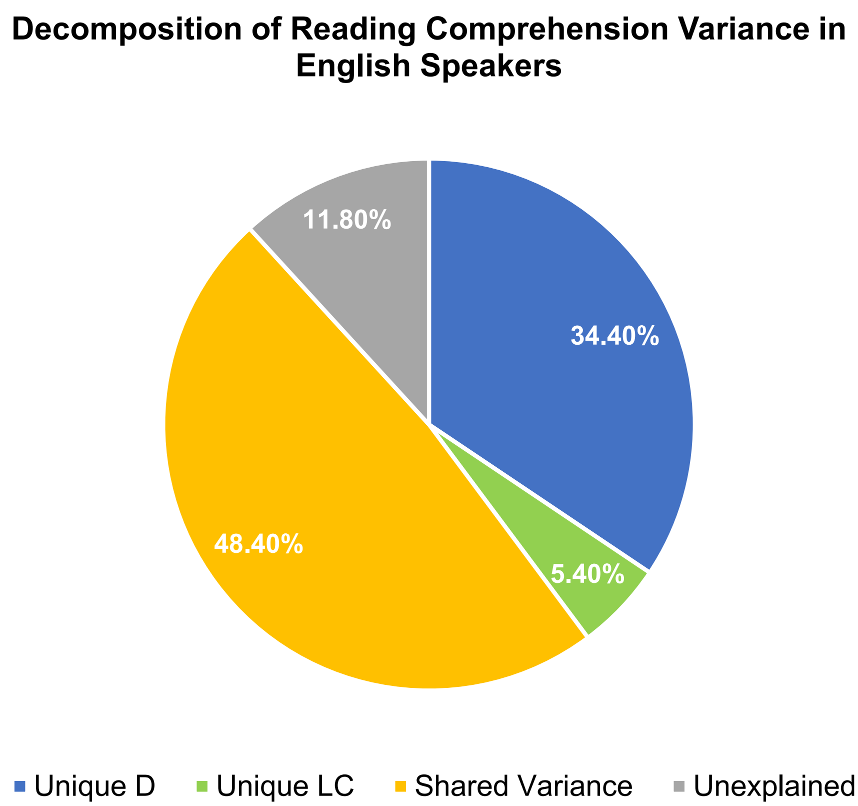
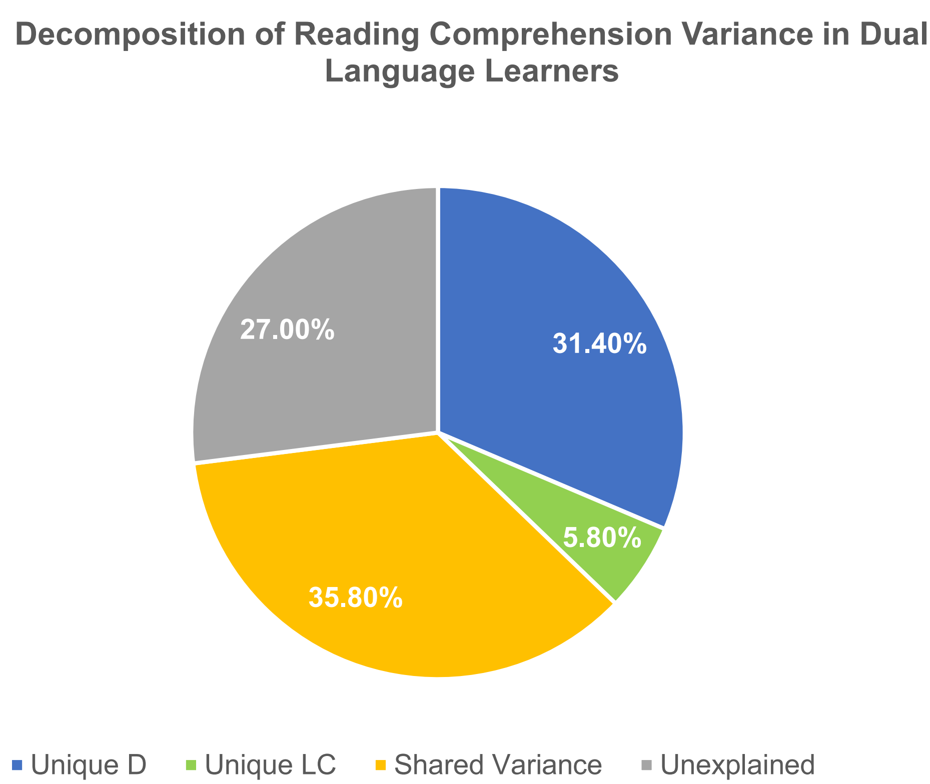


Figure 1.b.



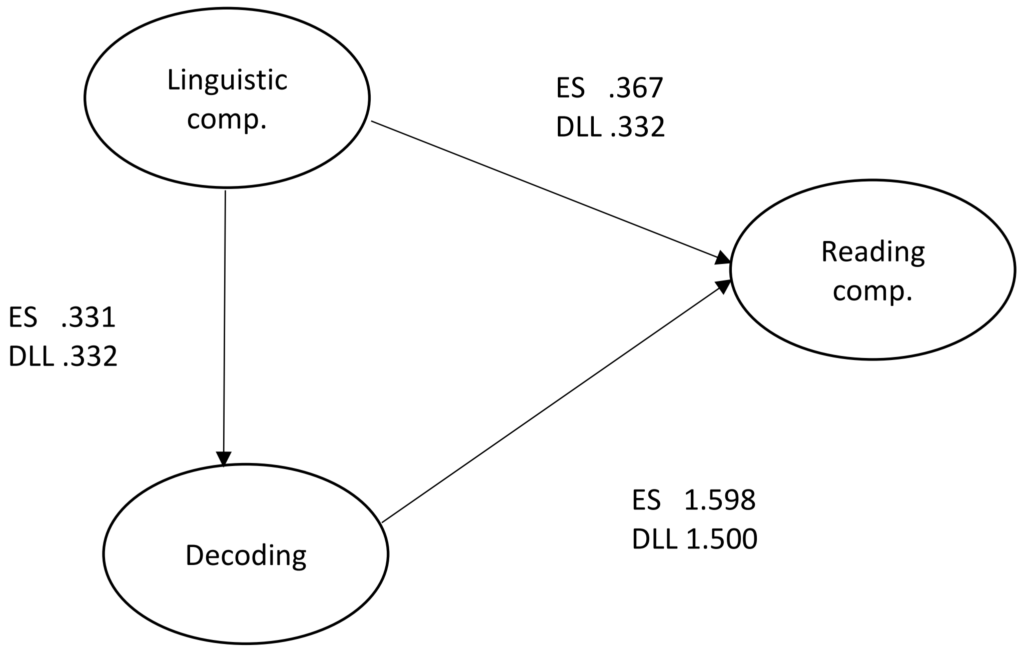


Figure 2. Structural model predicting reading comprehension from linguistic comprehension and decoding, controlling for grade level. Estimates are unstandardized. For clarity, bootstrapped bias-corrected 95% confidence intervals (CIs) for the estimates are presented in Table 4. None of the CIs included zero, indicating that all estimates are significant. No paths differed across groups. ES = English speaker. DLL = dual language learner.

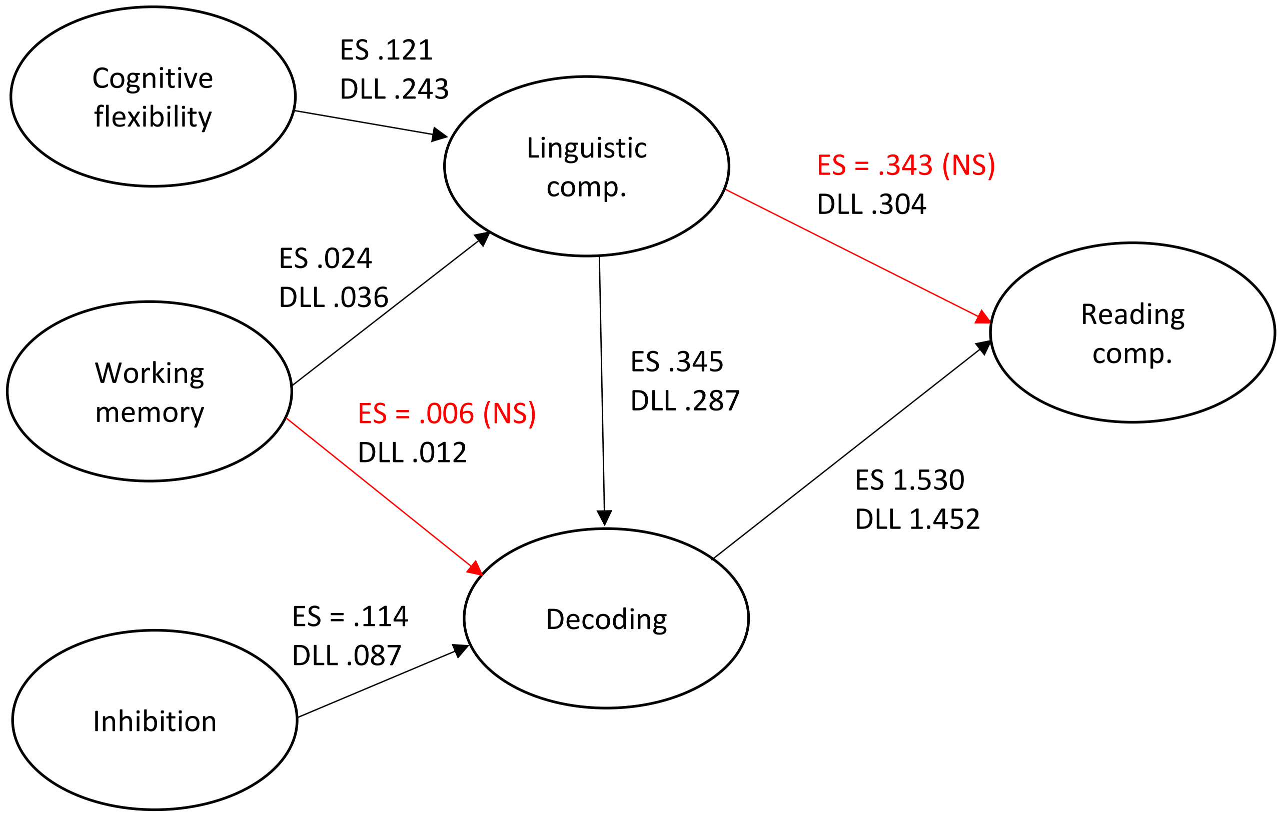


Figure 3. Structural model predicting reading comprehension from linguistic comprehension, decoding, and three executive functions, controlling for grade level. Estimates are unstandardized. For clarity, bootstrapped bias-corrected 95% confidence intervals (CIs) for the estimates are presented in Table 5. Based on CIs not including zero, all estimates are significant, except the estimates followed by NS (non-significant). No paths differed across groups based on 95% CIs for the difference estimates across groups. ES = English speaker. DLL = dual language learner.