



Language skills, and not executive functions, predict the development of reading comprehension of early readers: evidence from an orthographically transparent language

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Abstract

The simple view of reading proposes that the development of reading comprehension in early elementary school is best predicted by children's fluent decoding and oral language skills. Recent studies challenge this view and suggest that executive functions should also be included in this theoretical model; however, the empirical evidence is not strong enough to clearly support or refute this hypothesis. In this short-term longitudinal study, we used latent variables to test whether executive functions have direct effects on the development of reading comprehension in 184 Romanian second graders, beyond fluent decoding and oral language skills. The results indicated that the initial stages of reading comprehension were associated with executive functions, but only the language skills could independently predict the development of reading comprehension. Our findings show that executive functions do not have a significant direct effect on the development of reading comprehension in early readers beyond fluent decoding and oral language skills in languages with transparent orthography. The results also suggest that once children learn to decode well, their language skills (and not their executive functions) have a strong effect on the development of reading comprehension. Therefore, reading interventions in elementary school should stress on the development of oral language skills.

Keywords Reading comprehension · Executive functions · Language skills · Decoding

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Learning to read is a crucial milestone in a child's development. The purpose of learning to read is to comprehend the written text. The most widely acknowledged theoretical model that explains how reading comprehension develops in early elementary school is the simple view of reading (Gough & Tunmer, 1986). According to this theory, reading comprehension is the product of decoding skills and language comprehension. When students learn to decode effectively, they can easily and automatically (i.e. fluently) translate a string of letters into words (Hoover & Gough, 1990). The construct of language comprehension delineates the meaning-based aspects of language, such as listening comprehension, vocabulary, syntax or the ability to make inferences (Lervåg, Hulme, & Melby-Lervåg, 2017). While the construct is not very clearly defined—and in fact, Hoover and Gough (1990) used it interchangeably with listening comprehension—, several studies have demonstrated that language skills can be treated as a unidimensional construct given that the results of multiple language measures load together into one single linguistic factor (Hulme, Snowling, West, Lervåg & Melby-Lervåg, 2020).

Several empirical studies support this theoretical model. Among these, two recent long-term longitudinal studies showed that fluent decoding and language skills together with the effects of their interactions explain almost all of the variance (> 96%) in early stages of the development of reading comprehension, with language skills playing a crucial role in both early and later stages (Hjetland, Lervåg, Lyster, Hagtvet, & Melby-Lervåg, 2018; Lervåg, et al., 2017). These two empirical studies, along with several others (Cadime et al., 2017; Ho et al., 2017; Kim, 2017; Lonigan, Burgess, & Schatschneider, 2018; Protopapas, Simos, Sideridis, & Mouzaki, 2012; Tobia & Bonifacci, 2015; Torppa, et al., 2016) support the hypothesis that the two main predictors of the development of reading comprehension are fluent decoding and language skills.

Despite a well-established theoretical model of reading comprehension supported by empirical evidence, there are critics that see the simple view of reading as being too simplistic and incomplete (e.g., Hoffman, 2017). An increasing number of recent studies challenges this view by suggesting the existence of a third predictor of reading comprehension which might have effects above and beyond fluent decoding and oral language skills (Cirino et al., 2019; Follmer, 2018; Guajardo, & Cartwright, 2016; Liu, Sun, Li, Yeung, & Wong, 2018). This predictor is executive functions, a set of top-down cognitive abilities that control thoughts and behaviors (Miyake et al., 2000). Executive functions are difficult to define (Jurado & Rosselli, 2007) and difficult to measure (Karr et al., 2018) but they are generally assessed using multiple measures of abilities such as working memory, shifting (cognitive flexibility), inhibition, planning, and selective and sustained attention.

So what are the putative mechanisms behind a relationship between reading comprehension and executive functions? Since executive functions are diverse, several mechanisms have been suggested to explain this relationship. Some studies suggest that working memory plays an important role by supporting readers in performing the phonological processes necessary to decode accurately (such as identifying individual sounds and blending them) and by helping readers process and store information simultaneously (Christopher et al., 2012; Stipek & Valentino, 2015). Other studies suggest that visuospatial working memory help readers by recoding verbal

information into visual forms (Bayliss, Jarrold, Gunn & Baddeley, 2003; Pham & Hasson, 2014). Empirical evidence has shown that selective and sustained attention predicts reading comprehension because it has the potential to regulate the content of working memory and to keep the cognitive resources focused on tasks long enough to create a representation of the text (Arrington et al., 2014; Astle & Scerif, 2011; Commodari, 2017). Shifting is assumed to play an important role in facilitating text comprehension by allowing readers to quickly switch between different perspectives in a story, to create new meaning by connecting new and old information, or to be flexible in the use of strategies that facilitate comprehension, such as rereading or skimming (Fuhs, Farran, & Nesbitt, 2015; Kieffer, Vukovic, & Berry, 2013). Some studies suggest that inhibition supports reading comprehension by suppressing irrelevant information and minimizing the proactive interference from working memory (Borella, Carretti, & Pelegrina, 2010; Kieffer et al., 2013). Finally, planning is suggested to contribute to reading comprehension by enacting strategies used by readers both before and during reading, including monitoring and revising the text (Cutting, Materek, Cole, Levine, & Mahone, 2009; Sesma, Mahone, Levine, Eason, & Cutting, 2009).

Chief among the studies that investigate the association between executive functions and reading comprehension is a recent meta-analysis which found that the two constructs are moderately positively associated, particularly in young readers (Follmer, 2018). Follmer suggests that the existing literature supports a theoretical model of “executive function to account for variance in the comprehension of text above and beyond processes commonly ascribed to comprehension, including decoding, word reading, fluency, and vocabulary” (p. 14). The paper suggests a plausible alternative theoretical model of the development of reading comprehension in the early elementary school years which accounts for executive functions as a unique predictor of reading comprehension, beyond fluent decoding and oral language skills. However, the research included in this analysis did not provide compelling empirical evidence to support or to refute this theory due to several methodological limitations of the existing studies (see below). Furthermore, recently published studies that were not included in the meta-analysis had contradictory results, painting an incomplete and puzzling picture of the role of executive functions in the development of reading comprehension. On the one hand, Liu et al. (2018) found in a cross-sectional study that executive functions uniquely predicted reading comprehension beyond decoding and oral language skills among Chinese readers. Another recent cross-sectional study (Cirino, et al., 2019) showed that executive functions can have a very small but unique contribution to reading comprehension, beyond fluent decoding and oral language skills among English speaking children in upper elementary school in the US. On the other hand, a cross-sectional study conducted in the US on a sample of children aged 9 through 14 showed that the effects of executive functions on reading comprehension were fully mediated by fluent decoding and oral language skills (Spencer, Richmond, & Cutting, 2019). Thus, it is not clear whether—or under what circumstances—executive functions can uniquely predict reading comprehension beyond the simple view of reading theoretical model. The aim of this study is to advance knowledge in the field by testing this competing hypothesis.

Limitations of the existing research

The existing studies have several limitations. First, executive functions are inconsistently measured across studies, often using a limited number of tests. This is problematic for two reasons. Research has shown that each executive function can have differential effects on reading comprehension (e.g., Christopher et al., 2012; Kieffer et al., 2013). In addition, the participants' performance on these tasks always relies on other non-executive processes, which raises the issue of *task-impurity*, a consistent and substantial source of measurement error of executive functions (Miyake & Friedman, 2012). Thus, to test the assumption that executive functions have an effect on reading comprehension beyond fluent decoding and language skills and to minimize the measurement errors of executive functions, it is necessary to include multiple measures of executive functions and test their effect with latent variable constructs. Only a few recent studies have accomplished this goal (e.g., Spencer et al., 2019) and similarly rigorous research is still needed (see also Follmer, 2018; Keiffer et al., 2013).

Second, most studies that indicated an association between executive functions and reading comprehension were cross-sectional and did not explain the development of reading comprehension over time. For instance, only 4 out of 29 studies included in Follmer's analysis were longitudinal, and more recent studies had the same limitation (Cirino et al., 2019; Liu et al., 2018; Spencer et al., 2019). Yet, in order to understand the extent of which executive functions predict the development of reading comprehension, longitudinal studies are warranted (see also Keiffer et al., 2013).

A third issue is that language skills (one of the main predictors of reading comprehension) are strongly associated with executive functions in the early school years (Botting, et al., 2016; Gooch et al., 2016) and have the potential to explain the effects of executive functions on reading comprehension tasks (Nowens, Groen, & Verhoeven, 2016). Indeed, many studies that associated executive functions with the reading comprehension of elementary school children tested the executive functions using language-dependent tasks such as verbal working memory (Stipek & Valentino, 2015) or listening recall (Chrysochoou, Bablekou, & Tsigilis, 2011). Only a few studies adequately controlled for the potential confounding effects of language comprehension (Cirino et al., 2019; Spencer et al., 2019). Other studies completely omitted (e.g., Meixner et al., 2019) or minimally controlled for language skills (e.g., Garcia-Madruga, Villa, Gomez-Veiga, Duque & Elosua, 2014). This limitation is crucial because empirical research shows that some language measures can at least partially explain the association between some executive functions and reading comprehension measures (Chrysochoou et al., 2011; Nouwens, Groen, & Verhoeven, 2016; Spencer et al., 2019). Thus, to test whether executive functions predict the development of reading comprehension beyond language skills, studies that rigorously control for language skills with latent variables are warranted.

Fourth, the empirical studies that support the simple view of reading did not rigorously control for executive functions. For instance, the studies conducted by

Hjetland et al. (2018) and Lervåg et al. (2017) only controlled for verbal working memory. Yet, verbal working memory is expected to share an important variance with language skills as both skills rely on children's linguistic abilities. The limitations paint an incomplete picture of the executive functions. Thus, it is unclear whether using multiple executive functions into one latent variable construct might uniquely predict reading comprehension beyond fluent decoding and language skills.

Fifth, many of the studies included in Follmer's analysis to support the theory that executive functions have a unique contribution to reading comprehension beyond fluent decoding and listening comprehension were conducted in English-speaking countries. Yet, due to the important variability across populations and languages, testing the competing theoretical model on languages and cultures that are not typically represented in the research industry has become increasingly important to the advancement of knowledge in the field (Henrich, Heine, & Norenzayan, 2010). For instance, we know that the development rate of decoding written words and understanding their meaning is slower in languages with opaque orthographies (such as English) as compared with languages with transparent orthographies (such as Spanish) (Caravolas, Lervåg, Defior, Malkova, & Hulme, 2013). The literature that empirically tested the simple view of reading also showed that typical early readers decode relatively well by the end of the 1st grade in orthographically transparent languages such as Italian (Tobia & Bonifacci, 2015) or Finnish (Torppa et al., 2016) because these languages feature a relatively consistent correspondence between the graphemes (21 in Italian, respectively 29 in Finnish) and phonemes. Consequently, decoding skills play a minor role in the development of reading comprehension after the first year of formal reading instruction for the children learning to read in languages with transparent orthographies. In contrast, the effect of decoding skills on reading comprehension remains substantial among students learning to read in English, even in upper elementary school (Kim, 2017; Lonigan, et al., 2018). It likely takes significant cognitive effort for students reading in English to distinguish between the 44 phonemes and the 123 phonographs that must be understood in order to become successful readers (Eide, 2012). Such additional cognitive effort could place constraints on the development of reading comprehension via decoding skills among readers of English (Haft et al., 2019); therefore, the role of executive functions could be more important for students learning to read in English than for students learning to read in Spanish, Italian or Finnish. To the best of our knowledge, no study has tested explicitly the potential role of executive functions on early reading comprehension beyond the effects of fluent decoding and oral language skills in a language with transparent orthography.

Learning to read in Romanian

Romanian is a language that is seldomly represented in the reading research and has a rather transparent orthography (most sounds have a direct corresponding letter and only two sounds are made up of more than one letter). Children from Romania are formally introduced to the letters of the Romanian alphabet and to their

corresponding sounds as soon as they enter school, at about the age of 6 (Year 0). Reading instruction in Romania typically focuses on decoding accurately and fluently in the first two years of formal instruction (and less on reading comprehension—see samples of textbooks at www.manuale.edu.ro). By the end of the 1st grade (the second year of formal reading instruction), typical students in Romania can decode accurately and fluently, and they can identify the sounds of the spoken language with high accuracy (Dolean & Andronache, 2013). Thus, reading development in Romanian follows a similar pattern similar to that of the development of other orthographically transparent languages (Caravolas et al., 2013; Tobia & Bonifacci, 2015; Torppa et al., 2016).

The present study

Here we aimed to address the aforementioned limitations through a short-term longitudinal study that uses latent variables to investigate whether executive functions predict the development of reading comprehension beyond the effects of fluent decoding and oral language skills. This study is novel because it is testing for the first time the simple view of reading theoretical framework on a nationally representative sample of students from Romania. Since we aimed to measure the development of reading comprehension, and as reading instruction in Romania relies more heavily on comprehension starting with the 2nd grade, we chose to follow the development of these skills from the beginning of the 2nd grade to the end of the 2nd grade. Consistent with other studies from transparent orthographies (Tobia & Bonifacci, 2015; Torppa et al., 2016), and in contrast to other studies from opaque orthographies that sampled students from this age group (e.g., Kim, 2017) we expected oral language skills to have stronger effects and fluent decoding skills to have weaker effects on the development of reading comprehension. Furthermore, since we expected our students to have strong fluent decoding skills by 2nd grade and executive functions were found to affect students' performance in reading comprehension indirectly mostly via decoding skills (Haft et al., 2019; Spencer et al., 2019), we expected that the executive functions would not have a strong direct effect on reading comprehension.

Then, in this study we will test the potential unique contribution of executive functions to the development of reading comprehension by controlling for earlier reading comprehension skills. While several studies have reported important concurrent associations between executive functions and reading comprehension, to the best of our knowledge none of the existing longitudinal studies showed whether executive functions are able to explain variance in the development of reading comprehension beyond the effects of its initial level.

Another characteristic of this study is the measurement of the reading comprehension of a narrative text with an open-ended assessment (NARA) administered individually. The individual administration of a test with an open-ended format has been found to reliably measure comprehension and to eliminate the possibility that children would guess the correct answer even without reading the text (Bowyer-Crane, & Snowling, 2005; Cain & Oakhill, 2006; Keenan, & Betjemann, 2006).

At the same time, the open-ended format of the assessment can depend more on the expressive language skills of the participants than other test formats (Keenan, Betjemann & Olson, 2008), so we expected that language skills would have a rather strong effect on the development of reading comprehension.

Therefore, we hypothesized that the simple view of reading (and particularly the oral language skills) would predict most of the variance in the development of reading comprehension, even after controlling for a strong executive functions construct.

Method

Participants

One hundred and eighty-eight second grade students from Romania attending one of 32 classes from 17 different schools were initially selected at random to participate in this study. Four students transferred to other schools before the assessment started. The final sample included 184 monolingual students (92 boys, mean age: 8 years, age range: 7 years 5 months to 9 years 6 months). We ran several Fisher's exact tests (see McDonald, 2014) to compare the demographics of our sample with the demographics of elementary school population from Romania (www.insse.ro). The results indicated that our sample was not significantly different from the elementary school population of Romania in terms of distribution of gender ($p = .89$, 2-tailed), percentage of urbanization ($p = .39$, 2-tailed), and ethnicity ($p = .53$, 2-tailed). Notably, we did not include bilingual Hungarian and Roma minority children in our sample in order to prevent their language specificities from interfering with our findings. No data was available about the potential qualification for special education services since students in Romania are very rarely diagnosed with a developmental delay at this age and typically qualify for services only in upper elementary school. The national rankings of the participating schools was fairly well distributed across our sample, with 9 schools (33%) ranked in the 1st quarter, 9 schools (33%) ranked in the 2nd quarter, 4 schools (15%) ranked in the 3rd quarter and 5 schools (18%) ranked in the 4th quarter (www.ise.ro).

Procedures

The children were assessed individually at two time points, at the beginning (September–October) and at the end (April–May) of the 2nd grade. The Fall testing window lasted for about 3 weeks and consisted of three testing sessions, each lasting between 20 and 40 min. The executive functions were assessed in one testing session, the reading (fluent decoding, and reading comprehension) were assessed in another testing session, and the language skills (listening comprehension and vocabulary) were assessed in a third session (see below). The Spring testing window had only one testing session which assessed the students reading comprehension. During the longer testing sessions, children were allowed to take

a short break. Testing was conducted by trained research assistants in quiet rooms within the schools where the children were registered.

Measures

Reading comprehension was measured at both time points using form A of the Romanian version of Neale Analysis of Reading Ability—Second Edition (NARA II; Neale, 1997) (see also Lervag, Dolean, Tincas, & Melby-Lervag, 2019). The test administrators asked the children to read the passages silently and then answer the questions orally. The test includes 6 stories, with each one increasing in length and difficulty. Each story is followed by 4 (story 1) or 8 (stories 2–6) open-ended questions. The answer to each question was rated with 0 (incorrect) or 1 (correct), based on the suggested potential answers that were included in the test administration protocol. The answer ratings could have ranged from 0 to 44. The internal consistency in our sample was high at Time 1 ($\alpha = .95$) and Time 2 ($\alpha = .95$).

Listening comprehension was assessed at Time 1 in a manner similar to the reading comprehension measure, using form B of Neale Analysis of Reading Ability—Second Edition (NARA II; Neale, 1997) (see also Lervag et al., 2018). The only difference from the reading comprehension task was that, for this test, the assessors (and not the children) read the stories aloud. The internal consistency in our sample was high ($\alpha = .93$).

Vocabulary was measured at Time 1 with the expressive vocabulary subscale of the Romanian version of the Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV) (Wechsler, 2003). This is a word definition task, which includes 32 words of increasing difficulty. The words were read aloud by the test administrators and the children were required to define them. Each answer was coded with 0 (incorrect answer), 1 (partially correct) or 2 (correct). The internal consistency was high ($\alpha = .91$). Notably, in studies using latent variables, this task shares important variance with listening comprehension, but also captures oral language skills that are not typically captured in listening comprehension tasks (e.g. the ability to create definitions based on the formation of concepts, see also Melby-Lervåg, Hagen, & Lervåg, 2019).

Fluent decoding skills were measured at Time 1 using a Romanian fluent decoding assessment similar to the Test of Word Reading Efficiency—Second Edition (TOWRE-2 - Torgesen, Wagner & Rashotte, 2012). The test, which we had designed, tested and employed successfully in a prior study (Dolean, Melby-Lervag, Tincas, Damsa, & Lervag, 2019), included two independent lists of words (List 1) and non-words (List 2) with increasing complexity. The lists started with monosyllabic words/non-words (e.g. am/co) and gradually developed to 5-syllable words/non-words (e.g. gastronomie/pernodapufi). The children were required to read correctly as many words/non-words as they could in 40 s. Each word/non-word read correctly was marked with one point and the maximum number of points they could earn was 80. There was a positive strong correlation between the two tests ($r = .94$).

Executive functions measures

All EFs indicators were assessed at Time 1. We selected most EFs included in Follmer's (2017) analysis i.e. verbal working memory, inhibition, cognitive flexibility and selective and sustained attention. In addition to working memory, we measured visuospatial memory (Bayliss, Jarrold, Gunn & Baddeley, 2003; Pham & Hasson, 2014). Although planning was also included in the meta-analysis, we did not include it in our study because this is a higher-level construct which typically does not explain unique variance after accounting for working memory, inhibition and shifting (Miyake and Friedman 2012). In addition, testing planning would have added a significant amount of time to our already time-consuming assessment battery, with the risk that it would have been a redundant and an unnecessarily burdensome assessment.

Selective and sustained attention was assessed with the *Visual Attention* test from the NEPSY battery (Korkman, Kirk, & Kemp, 2007; see Petra & Porumb, 2005 for the Romanian version). During this task, the test administrator presented the child with a visual display on a paper which included a target stimulus and several items (both targets and distractors). The child was asked to correctly identify the target stimulus among the distractors by crossing it out with the pencil. The test included two visual displays and the children's performance was timed. The number of correctly identified targets for each of the two visual displays were summed and then converted into standardized scores based on their response time. The total possible score ranged from 0 to 51.

Verbal working memory was measured with a backward digit recall test, in which the child was asked to recall a gradually increasing sequence of spoken digits in the reverse order. The series of digits were presented in an order of increasing difficulty. One point was awarded for each item repeated correctly. The testing was discontinued when a child failed to recall correctly two consecutive lists. The internal consistency of this measure was high ($\alpha = .85$).

Visuospatial memory was assessed with CORSI blocks test (Corsi, 1972) using a display from WAIS-R Neuropsychological Inventory (Kaplan, Fein, Morris, & Delis, 1991). The display had 10 blocks and the test administrator used an index finger to tap a sequence of blocks at the rate of one block per second. The child was required to mimic the test administrator by tapping the blocks in the correct sequence. The task started out with sequences of only two blocks and, gradually increased in difficulty by adding more blocks to the sequence. One point was awarded for each sequence reproduced correctly. The testing was discontinued when a child failed to mimic correctly two consecutive sequences. The internal consistency was high ($\alpha = .83$).

Inhibition and shifting was measured with the two correspondent subtests from the Inhibition task of NEPSY-II (Korkman, Kirk, & Kemp, 1998). During this task, we measured the children's ability to inhibit automatic responses in favor of alternative responses (Inhibition subtest) and to shift between automatic and cognitively controlled responses (Switching subtest). For each of the two subtests, the test administrator showed the children a display of black and white shapes (Shape display) or a display of arrows pointing in various directions

(Arrows display). During the Inhibition subtest, the child had to rapidly name the opposite shape (e.g. *say square when you see a circle*) or the opposite direction (e.g. *say up when the arrow is pointing down*). During the Switching subtest, the child had to say the correct shape or arrow's direction if the object was colored white, or the opposite shape or arrow's direction if the object was colored black. One point was given for each item named correctly. Time to complete the test was also recorded. The effectiveness of performance was calculated by dividing the total accuracy score by the number of seconds necessary to complete the task, and this procedure generated one effectiveness output for Inhibition and one effectiveness output for Switching. Each subtest was scored separately, and the total possible score ranged from 0 to 40.

Statistical analyses

To test our hypothesis we used three autoregressive structural equation models (SEM) where reading comprehension was regressed on (1) fluent decoding skills and language skills (to replicate the simple view of reading), (2) executive functions (to establish a possible relationship between executive functions and reading comprehension) and (3) fluent decoding skills, language skills and executive functions (to test if executive functions can contribute to reading comprehension beyond language and decoding). The decoding construct (Time 1) was reflected by word and nonword efficiency, the language construct was reflected by vocabulary and listening comprehension and executive functions were reflected by shifting, inhibition, sustained attention, verbal working memory and visuospatial memory. As reading comprehension had only one indicator, we fixed the residual of this variable to reflect the alpha reliability. This was done to estimate the true score variance of the variable.

Further, since interactions and curvilinear effects between fluent decoding and language skills and reading comprehension has been found in earlier studies (see Hjetland et al. 2018 and Lervåg et al., 2017) and because the simple view of reading suggests an interaction between decoding and language skills (Gough & Tunmer, 1986), we tested for this and included the effects, if significant. The interaction and the curvilinear effects were tested for reading comprehension at both Time 1 and Time 2. To do this we used the default with command for interactions and curvilinear effects in Mplus.

To judge the fit between the estimated model and the data, we followed Hu and Bentler's (1999) suggestions of either a combination root mean square error of approximation (RMSEA) below .06, and standardized root mean residuals (SRMR) below .06 a combination of the Comparative fit index (CFI) or the Tucker-Lewis index (TLI) above .95 and the SRMR below .08.

All these analyses were done in Mplus version 8 (Muthén & Muthén, 1998–2018) using full information maximum likelihood (FIML) to handle missing data and robust maximum likelihood with Huber-White corrections (MLR, Complex) to account for potential dependency within schools.

Table 1 Correlations and descriptive statistics of the measured variables

Variable	1	2	3	4	5	6	7	8	9	10	11
1. Reading comprehension Time 1	–										
2. Reading comprehension Time 2	.858**	–									
3. Listening comprehension	.725**	.743**	–								
4. Vocabulary	.732**	.713**	.655**	–							
5. Decoding words	.602**	.576**	.435**	.540**	–						
6. Decoding non-words	.563**	.536**	.403**	.461**	.937**	–					
7. Selective and sustained attention	.190**	.229**	.197**	.208**	.355**	.324**	–				
8. Verbal working memory	.473**	.426**	.421**	.438**	.496**	.506**	.246**	–			
9. Visuospatial memory	.401**	.368**	.336**	.340**	.357**	.380**	.249**	.555**	–		
10. Inhibition	.416**	.479**	.408**	.338**	.397**	.420**	.349**	.469**	.459**	–	
11. Shifting	.476**	.504**	.423**	.425**	.511**	.520**	.350**	.534**	.508**	.732**	–
<i>M</i>	16.01	21.20	18.53	21.99	32.18	23.24	14.47	10.59	18.16	.40	.24
<i>SD</i>	10.25	10.92	8.98	11.13	15.80	10.47	5.36	3.82	4.11	.12	.08
Minimum	0	0	0	0	0	0	1	0	8	.11	.00
Maximum	43	44	40	51	70	51	31	28	28	.69	.42
Skewness	.46	.01	.04	.30	.34	.35	–.02	1.33	–.11	–.05	–.19
Kurtosis	–.56	–.91	–.85	–.70	–.57	–.21	.04	4.65	–.56	–.15	–.03

**Correlations significant at 0.01 level

Results

Means, standard deviations and correlations for all variables are shown in Table 1. As can be seen, reading comprehension was stable across time and all variables correlated significantly with each other. Three positive univariate outliers ($p < .001$) were found for backwards digit span and were recoded into the highest non-outlier value plus one.

The SEM model replicating the simple view of reading is shown in Fig. 1. As can be seen, both fluent decoding and language skills measured at Time 1

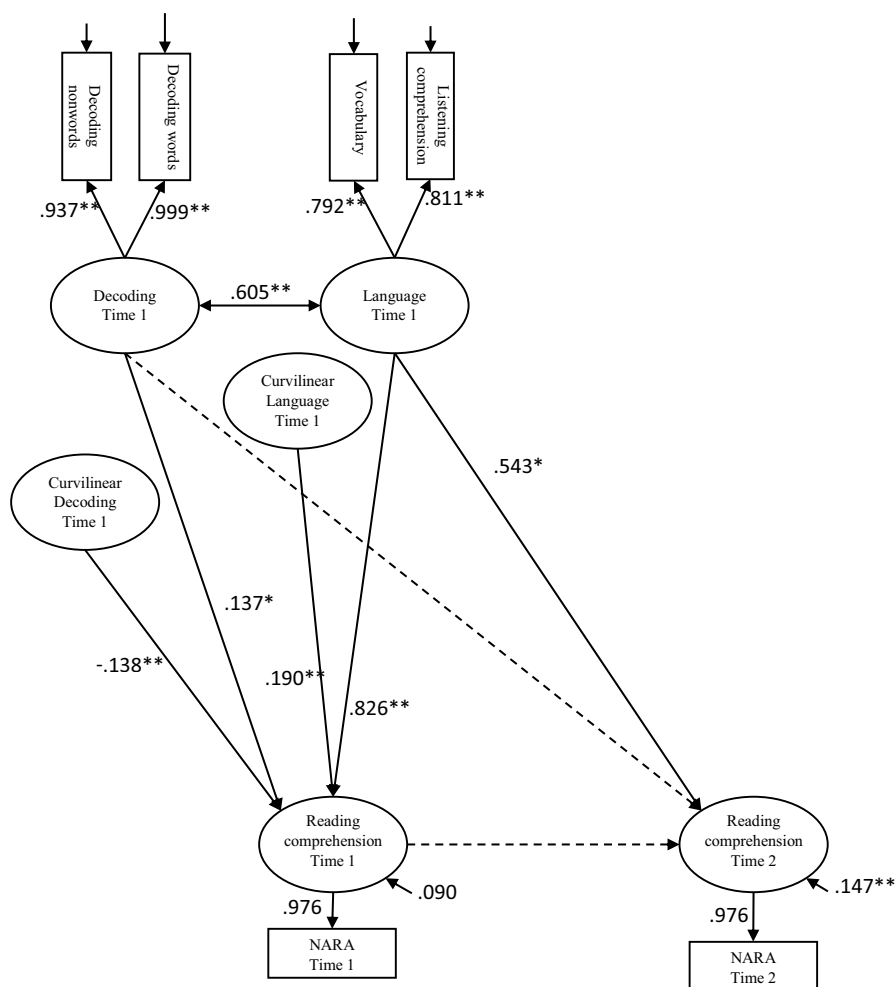


Fig. 1 Reading Comprehension at Time 1 and 2 predicted from Decoding Skills and Language Skills at Time 1. Two-headed arrows reflects correlations and one-headed arrows reflects regressions (paths). Paths with whole lines between the constructs (ellipses) are significant and paths and arrows with dotted lines are estimated but non-significant. * = $p < .05$, ** = $p < .01$

explain variance in reading comprehension at Time 1 but only language skills explain variance in reading comprehension at Time 2 after controlling for reading comprehension at Time 1. Also, fluent decoding is more strongly associated with reading comprehension at Time 1 among the poor decoders as compared to the good decoders. This is shown by the negative curvilinear relationship between fluent decoding and reading comprehension in Fig. 1. For language, the curvilinear relationship was opposite, i.e. variation in language skills is more strongly associated with reading comprehension among those with better language skills. A total of 85.7% and 86.6% of the variance in reading comprehension at Time 1 and 2 respectively were accounted for in this model. This model without the curvilinear effects (Mplus does not report these fit measures with the integration algorithm necessary to estimate the curvilinear effects) fitted the data very well, $\chi^2(6) = 10.243$, $p = .115$, RMSEA = .062 (10% CI = .000–.125), CFI = .994, TIL = .985, SRMR = .019.

The SEM testing the possible relationship between executive functions and reading comprehension is shown in Fig. 2. As can be seen, executive functions were able to explain a large portion of the variance in reading comprehension at Time 1 but were not able to explain variation in reading comprehension at Time 2 beyond the impact of reading comprehension at Time 1. To improve the fit of the model, the residuals of shifting and inhibition were correlated. We found this reasonable as both tasks relied on the timed naming of shapes which typically results in large correlations between subtests (e.g. Brooks, Sherman, & Strauss, 2010), and because shifting has been shown to rely developmentally on inhibition (e.g. van der Ven, Kroesbergen, Boom, & Leseman, 2013). This model fitted the data very well, $\chi^2(12) = 17.561$, $p = .130$, RMSEA = .050 (10% CI = .000–.097), CFI = .990, TIL = .982, SRMR = .028.

In the last SEM we combined the two former models to see the degree to which executive functions are related to reading comprehension beyond fluent decoding and language skills. As shown in Fig. 3, fluent decoding and language skills explained variation in reading comprehension at Time 1 with curvilinear effects. Consistent with the findings of Lervåg et al. (2018), fluent decoding explained more variance in reading comprehension among the poor readers as compared to the good readers, and language explained more variance in reading comprehension among the good readers as compared to the poor readers. Neither the interaction between fluent decoding and language skills nor the executive functions were able to explain additional variance in reading comprehension at Time 1. Further, language at Time 1 was the only construct able to explain variations in reading comprehension at Time 2 after controlling for reading comprehension at Time 1. Strong correlations between fluent decoding, language skills and executive functions suggest that the common variance between these three constructs were substantial (from 37.0% to 46.1%). A total of 91.7% and 86.0% of the variance in reading comprehension at Time 1 and 2 respectively were accounted for in this model. This model without the curvilinear effects fitted the data very well, $\chi^2(35) = 54.989$, $p = .025$, RMSEA = .053 (10% CI = .020–.081), CFI = .986, TIL = .977, SRMR = .031.

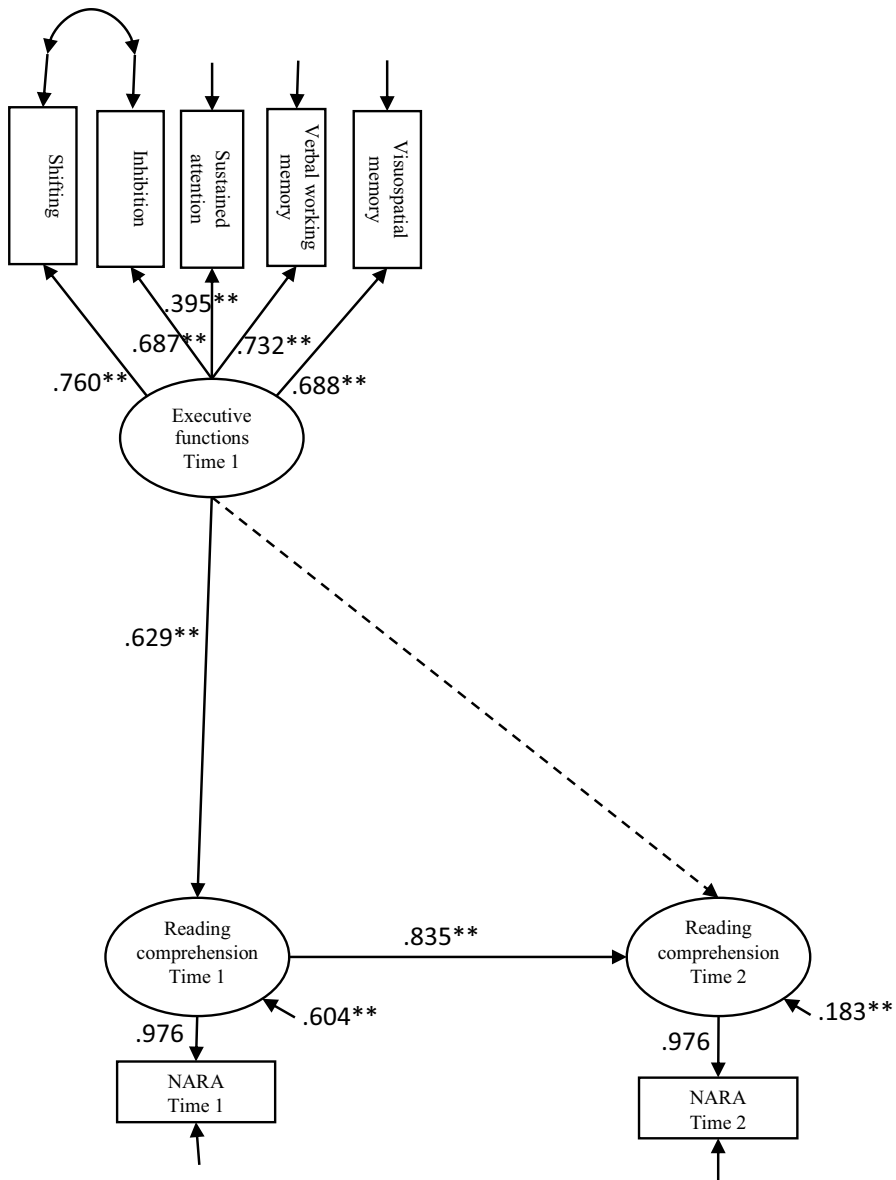


Fig. 2 Reading Comprehension at Time 1 and 2 predicted from Executive Functions at Time 1. Two-headed arrows reflects correlations and one-headed arrows reflects regressions (paths). Paths with whole lines between the constructs (ellipses) are significant and paths and arrows with dotted lines are estimated but non-significant. $^{**} = p < .01$

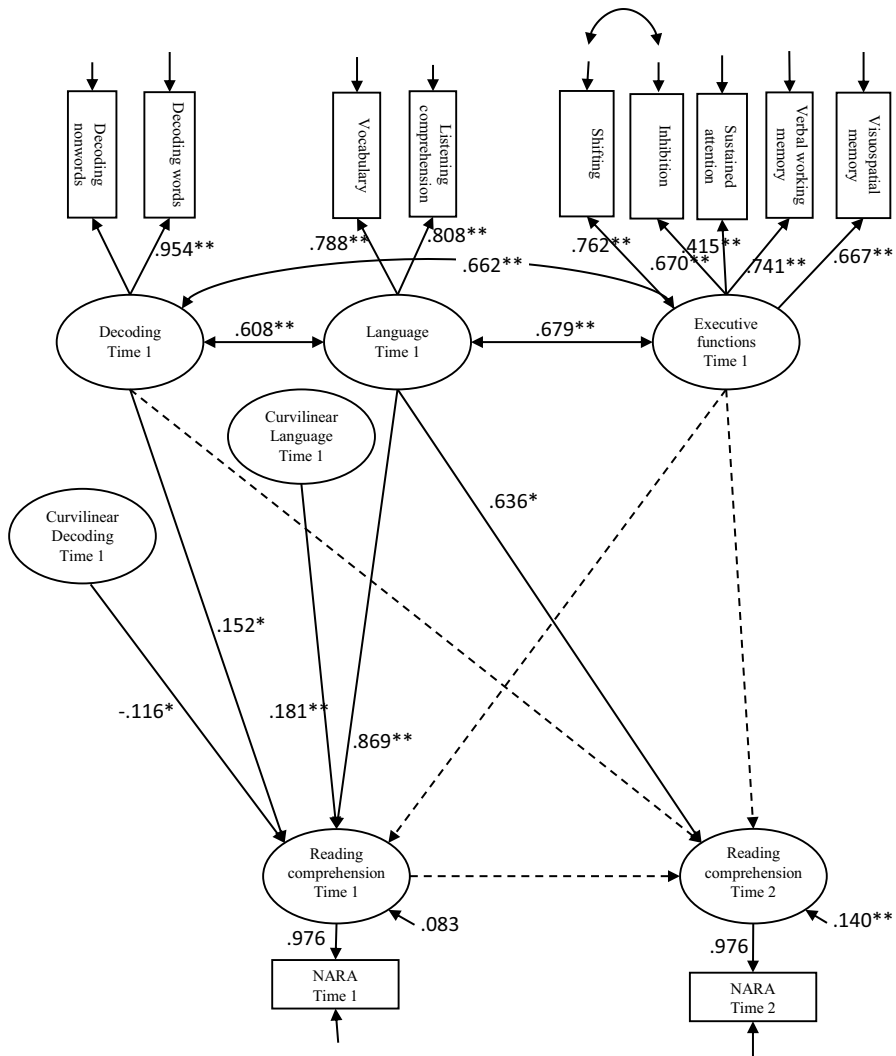


Fig. 3 Reading Comprehension at Time 1 and 2 predicted from Executive Functions, Decoding Skills and Language Skills at Time 1. Two-headed arrows reflects correlations and one-headed arrows reflects regressions (paths). Paths with whole lines between the constructs (ellipses) are significant and paths and arrows with dotted lines are estimated but non-significant. $* = p < .05$, $** = p < .01$

Discussion

The aim of this study was to test whether the executive functions can explain the development of reading comprehension beyond the effects of fluent decoding and oral language skills. Our results showed that even a rigorously measured executive functions construct could not explain the development of reading comprehension of early readers in a language with transparent orthography beyond the theoretical

framework of the simple view of reading (Gough & Tunmer, 1986). These findings are compelling, particularly because our executive functions latent variable showed not only a moderate (Follmer, 2018) but a strong association with the reading comprehension at the beginning of second grade. Our findings showed that fluent decoding and the oral language skills explained most of the variance (92%) in reading comprehension, providing another strong support for the simple view of reading. While this is the first study to test this theoretical model on a sample of children speaking Romanian, our findings replicate the research on samples of children speaking English (Lonigan, et al., 2018), Norwegian (Lervåg, et al., 2018), Greek (Protopapas et al., 2012), Portuguese (Cadime et al., 2017), Italian (Tobia & Bonifacci, 2015), Finnish (Torppa, et al., 2016) and Chinese (Ho, et al., 2017). These consistent results strengthen the generalizability of the simple view of reading. Our results indicate that executive functions share important variance with the two key predictors of reading comprehension (i.e., fluent decoding and language), but their effect was not strong enough to have a direct influence on the development of reading comprehension after accounting for these traditional predictors. On the one hand, our findings are inconsistent with previous research which suggested that executive functions can uniquely predict reading comprehension beyond fluent decoding and language skills (Cirino et al., 2019; Liu et al., 2018).

On the other hand, our findings are consistent with the recent findings of Spencer et al. (2019) in the sense that executive functions did not predict reading comprehension beyond the effects of fluent decoding and language skills. However, our study contributed beyond this previous study in two ways. First, unlike the cross-sectional design used by Spencer et al., our study followed the students longitudinally, thus allowing us to identify the crucial role of oral language skills (but not executive functions) on the improvement of reading comprehension skills between fall and spring. Second, unlike the study reported by Spencer et al., we tested our hypothesis on a sample of students speaking an orthographically transparent language. To the best of our knowledge, there are no other studies that test the potential unique effects of executive functions beyond the traditional predictors of reading comprehension outlined in the simple view of reading on a sample of students that speak an orthographically transparent language.

So how can we explain the inconsistent findings regarding the predictive strength of the executive functions on reading comprehension? One plausible explanation is that executive functions might not have a strong effect on reading comprehension among students who are decoding fluently. This is the case in our study, where the fluent decoding skills tested in the fall did not have a significant effect on the spring reading comprehension scores. Similarly to our study, Spencer et al. did not find unique effects of executive functions on reading comprehension in a sample of students whose fluent decoding skills did not contribute to their reading comprehension nearly as much as their oral language skills (although they found indirect effects mostly via decoding, and limited indirect effects via oral language). In contrast, Cirino et al. found a direct effect of executive functions on reading comprehension in a study oversampled with struggling readers. In this study the contribution of the fluent decoding skills to reading comprehension was much stronger than the effects of oral language skills. These

findings suggest that the effects of the executive functions on reading comprehension could be stronger via decoding skills (Haft et al., 2019; Spencer et al., 2019) but they also support our findings by suggesting that these effects decrease as the students become better decoders.

Another plausible explanation for the results of studies that found direct effects of executive functions on reading comprehension might be explained by measurement errors. For instance, Liu et al. (2018) used only one variable for each predictor of reading comprehension, which increased the possibility of measurement errors. In our study we minimized the occurrence of such errors by using latent variables. In addition, although it is not clear how the students were assessed by Cirino et al. (2019), it is plausible that they were tested in groups, given their large sample size and their use of tests which allow for group administration (e.g., Gates-MacGinitie). In this case, the children's performance on reading comprehension assessments could have been influenced by environmental factors. We have minimized this possibility by assessing our students individually.

Another take away message from our study is that in transparent orthographies, the oral language is a strong predictor of the development of reading comprehension even among early readers (see also Hjetland et al., 2018; Lervåg et al., 2017; Tobia & Bonifacci, 2015; Torppa et al., 2016). Our results suggest that in transparent orthographies, the curvilinear effect of fluent decoding skills on reading comprehension fades out by second grade, while the effects of oral language skills become stronger at an early developmental stage (Lervåg et al., 2018). The same curvilinear effect can be found in languages with opaque orthographies, but the effect of oral language skills becomes stronger than the effect of fluent decoding at a later developmental stage. For instance, Kim (2017) found that fluent decoding has a stronger effect on reading comprehension than oral language among second grade students who learn to read in English, while Lonigan et al. (2018) found that the effect of oral language skills becomes stronger than the effect of fluent decoding skills only when students reach fourth grade. These findings suggest that the patterns of reading development are similar across orthographies, but for students learning to read in transparent orthographies, the effect of oral language skills is stronger at an earlier developmental stage.

The strong effect of oral language skills suggests that intervention programs aimed to improve language skills could lead to an improvement in reading comprehension. A recent meta-analysis that included experimental and quasi-experimental studies showed that language intervention programs have the potential to lead to transfer effects on standardized language and reading comprehension measures (Rogde, Hagen, Melby-Lervåg, & Lervåg, 2019). Although the results were not always consistent, such transfer effects are shown to be particularly effective through programs that enhance expressive rather than the receptive language skills (Melby-Lervåg, et al., 2019). Thus, intervention studies that aim to improve the expressive language skills of elementary school students have the potential to lead to far transfer effects in reading comprehension.

Limitations and future research

Our findings need to be treated with caution for several reasons. First, the open-ended reading comprehension task that we used in this study relied heavily on the students' expressive language skills. In our study, both vocabulary and listening comprehension tasks assessed the students' expressive language skills. Research has shown that students' performance on reading comprehension tests could vary as a function of the type of the comprehension task used, and the performance on such open-ended comprehension tasks relies more on the students' oral language skills than on their decoding skills (Keenan, Betjemann, & Olson, 2008). Further research could benefit if it would include multiple measures of reading comprehension.

Second, in this study we only included a sample of typically developed 2nd graders. In order to strengthen the generalizability of our findings, more research is necessary to replicate this study with samples of children from different age groups.

Another limitation of our study was that we only included a sample of Romanian speaking children. More research is warranted with samples of early readers speaking languages with varied orthographic transparency (preferably cross-linguistic studies) as it might be possible that the effects of executive functions on reading comprehension could vary as a function of language and orthographic transparency (Holloway, van Atteveldt, Blomert, & Ansari, 2015).

Finally, our longitudinal feature of this study needs to be treated with caution, as we have measured the reading comprehension performance at only two time points. Further research is warranted to include measures of reading comprehension at multiple time points.

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