Reading comprehension and Immersion schooling: Evidence from component skills

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Research highlights

- We investigated the acquisition of reading comprehension in school-aged children attending monolingual versus L2 immersion programs.
- Linguistic processing and Memory & Reasoning were identified as principal components underlying reading comprehension at the sub-skill level.
- L2 immersion children showed a delay in linguistic processing, but increased memory and reasoning abilities relative to monolinguals.
- Reading comprehension was equivalent in both groups, suggesting compensation effects for differentially affected sub-skills.

Abstract

The present research aims to assess literacy acquisition in children becoming bilingual via second language immersion in school. We adopt a cognitive components approach, assessing text-level reading comprehension, a complex literacy skill, as well as underlying cognitive and linguistic components in 144 children aged 7 to 14 (72 immersion bilinguals, 72 controls). Using principal component analysis, a nuanced pattern of results was observed: although emergent bilinguals lag behind their monolingual counterparts on measures of linguistic processing, they showed enhanced performance on a memory and reasoning component. For reading comprehension, no between-group differences were evident, suggesting that selective benefits compensate costs at the level of underlying cognitive components. Overall, the results seem to indicate that literacy skills may be modulated by emerging bilingualism even when no between-group differences are evident at the level of complex skill, and the detection of such differences may depend on the focus and selectivity of the task battery used.

Bilingual immersion education refers to a pedagogical concept where curricular content is taught in a language other than the students' native or home language. The language of schooling is typically a minority language within the community or societal context, and the goal is for children undergoing immersion to achieve maximum - ideally native-like - proficiency in the target language (Wright, 2013). While the motivations for immersion schooling are multifaceted (among the most important, enhancing career prospects, protecting cultural heritage, promoting multicultural integration) and tend to be differentially weighted across countries (Johnson & Swain, 1997), bilingual immersion programs are growing in popularity and numbers everywhere around the globe. In light of this ongoing trend, questions regarding the academic, linguistic and cognitive effects are highly topical. Systematic research is still sparse, although researchers have long expressed the need to systematically evaluate the linguistic and academic outcomes of immersion schooling and have started to do so as early as the 1970s. Most of this research comes from Canada, where there has been a long-standing tradition of French-immersion programs in Anglophone areas (Wright, 2013, but see Oller & Eilers, 2002). Therefore, the relevant body of data is almost entirely limited to the Canadian school system, immigration system and society as a whole, as well as L1 English-L2 French as a specific language combination. The present study centers on reading comprehension in school-aged native speakers of Spanish in English immersion schooling, a sample pertaining to a rapidly growing but thus far understudied population.

An important issue of concern regarding L2 immersion education has been whether it is associated with any adverse consequences for the development of the native, majority language. Concerns have been raised by researchers from the educational and the cognitive field. From a pedagogical-educational viewpoint, the key issue is whether curricular objectives for language and literacy are achieved at a pace comparable to the monolingual norm. In bilingual immersion schooling, most classroom interaction, including explicit instruction in literacy skills, is limited to the L2. It is thus possible that the acquisition of higher order L1 language and literacy skills might be delayed relative to the standard, monolingual schooling in the L1.

From the cognitive perspective, performance on the higher order language skills that are explicitly taught relies on a number of underlying cognitive and linguistic skills and processes that are still developing. Phonological and orthographic ability, morphological knowledge, as well as vocabulary and syntax comprehension are critical for both lexical reading skill and supralexical reading comprehension, whereas the latter additionally relies on verbal memory capacity, reasoning and inference processes (Bowers, Kirby & Deacon, 2010; Cain, 2007; Cutting & Scarborough, 2006; Oakhill, Cain & Bryant, 2003; Perfetti, Marron, & Foltz, 1996). Reading speed is another factor that has been discussed as a basic component of reading comprehension (Adlof, Catts & Little, 2006; Cutting & Scarborough, 2006; Joshi & Aaron, 2000). The contribution of component processes may differ with grade level (Diakidoy, Stylianou, Karefillidou & Papageorgiou, 2005; Tilstra, McMaster, Van den Broek, Kendeou & Rapp, 2009), across languages and writing systems (Saiegh-Haddad & Geva, 2008; Ziegler et al., 2010), as well as bilingual status (monolingual vs. bilingual children of different language pairs, Marinova-Todd, Siegel & Mazabel, 2013), and there may be complex interactions between these factors. For example, the strength of the relationship between morphological awareness and reading in English appears to depend on whether children know an additional language (in this case always as the L1), and the degree of morphological transparency of that language (Marinova-Todd et al., 2013).

In addition, accumulated data from cognitive linguistics research over the last two decades show that bilingual and monolingual minds often function differently even when overt performance is comparable. Full immersion students, even those from a monolingual background, usually reach functional, and in some aspects native-like, proficiency in a second language (Harley, Allen, Cummins & Swain, 1991) and are therefore best characterized as *emergent* bilinguals. For earlier, more balanced bilinguals, selective advantages and drawbacks in linguistic and nonlinguistic domains have been observed (Bialystok, 2001, 2010), and there is some evidence to suggest that pertinent findings may extend to L2 immersion students (Bialystok, Peets, & Moreno, 2014). These observations are important from a cognitive components perspective, as they suggest there may be at least two ways in which bilingual immersion schooling might affect the acquisition of reading comprehension and literacy: directly, through (limited) exposure and instruction in L1 curricular content, or indirectly, by virtue of processing differences at the level of component skills that result from the emergent bilingual status.

As far as educational research into L1 literacy skills goes, some deficits have in fact been observed in English-French immersion students compared to monolingual age peers. More specifically, children undergoing full L2 immersion tend to show a temporary delay in L1 literacy skills including letter-sound conversion, spelling, as well as lexical and higher-level reading abilities (Barik & Swain, 1975, 1976a, 1976b; Genesee & Stanley, 1976; Harley, Hart & Lapkin, 1986; Kendall, Lajeunesse, Chmilar & Shapson, 1987; Lambert & Tucker, 1972; Lapkin & Swain, 1984; Swain & Lapkin, 1982; Turnbull, Hart & Lapkin, 2003; for reviews, see Bournot-Trites & Tellowitz, 2002; Genesee & Jared, 2008). These early studies followed several cohorts longitudinally and consistently replicated an initial delay, which later disappears (and sometimes reverts) after several years of schooling and introduction of the L1 as a supplementary medium of instruction. The most persistent delay is observed for spelling, while oral skills appear to be less affected (Barik & Swain, 1975, 1976a, 1976b; Lambert & Tucker, 1972). This pattern is plausible in light of the fact that the acquisition of written language relies on formal instruction much more than oral language. Notably, past research shows that the linguistic deficits in bilinguals are relatively minor and largely temporary despite the lack or limitation of explicit instruction, which suggests that literacy skills may transfer from L2 to L1. Research suggests that such transfer is, in principle, possible, but might depend on the language pair (Ramirez, Chen, Geva, & Kiefer, 2010).

Evidence from early, more balanced bilinguals, on the other hand, often shows a characteristic pattern of cognitive and linguistic abilities in bilingual relative to monolingual children: while the acquisition of formal knowledge of language, like vocabulary and grammar, may be delayed, metalinguistic skills like morphological, syntactic, phonological or word awareness tend to be temporarily (in the case of phonological awareness) or persistently (in the case of morphological awareness) enhanced (for reviews, see Bialystok, 2002, 2005, 2007, 2010). Another persistent finding is relatively slower lexical access in bilinguals across lifespan development (e.g., Ivanova & Costa, 2008; Michael & Gollan, 2005; Yan & Nicoladis, 2009).

Research investigating whether, and under which conditions, these findings also apply to L2 immersion students is very limited. One study confirmed an advantage for morphological awareness, combined with a temporal delay for verbal fluency using a letter fluency task in L2 immersion students compared to monolinguals (Bialystok, Peets, & Moreno, 2014). Tingley and colleagues (2004) observed no differences between children attending L1 monolingual vs L2 immersion programs regarding phonological awareness in the early school years, but, consistent with the earlier literature, showed a disadvantage for immersed children in word recognition at this age. In addition, a few studies compared the development of L1 versus L2 linguistic and metalinguistic skills, including vocabulary, lexical access, phonological and morphological awareness *within* samples of L2 immersion students (e.g., Comier & Kelson, 2000; Hermanto, Moreno & Bialystok, 2012; Joy, 2011). Data from these studies suggest that in L2 immersion schooling, L1 skills tend to evolve at a slower pace than L2 skills (Joy, 2011) and the acquisition of formal linguistic knowledge is delayed relative to metalinguistic development (Hermanto et al., 2012). However, these studies did not implement a monolingual control group and thus do not allow one to compare performance across different school types. All of these studies were based on L1-English children immersed into L2-French at school.

The sum of between-group differences in formal linguistic knowledge and language processing might render bilingual language processing relatively more effortful than is the case for monolinguals. Arguably, this might carry over to the level of complex skill and academic outcomes observed on the surface. At present, research into the cognitive consequences of bilingual immersion schooling at the level of cognitive processes is still at its beginning stages. To our awareness, there is no systematic research linking these patterns of monolingual vs. bilingual costs and benefits to a complex literacy skill like reading comprehension. In addition, early evaluations of reading ability in immersion students (e.g., Barik & Swain, 1975, 1976a, 1976b) did not tend to distinguish reading comprehension at the text level from reading skill at the sentence or word level, and often did not test inference-skills. The present article seeks to integrate educational and cognitive approaches. Our main focus is on text-level reading comprehension, a complex cognitive skill that is taught as part of school curricula and is crucial to general academic achievement and continuous knowledge acquisition throughout the lifespan. As discussed above, reading comprehension has been identified as a potential problem area in children undergoing L2 immersion schooling (Cummins, 1998). To gain a thorough understanding of children's performance, in addition to written text comprehension, we will assess a series of underlying and related component processes, including vocabulary knowledge, lexical access in production and comprehension, phonological and morphological abilities, verbal working memory and long-term memory, as well as sentence-level syntactic comprehension. This cognitive components approach allows us to gain theoretically and practically relevant insights: if a deficit does exist at the complex skill level, we might be able to localize the source in the form of a subjacent component factor that might present a bottleneck. If a bilingual advantage is observed, we can pinpoint the factors that bring about this advantage. Even if no overt discrepancies are observed at the level of complex skill, there might nevertheless be underlying qualitative processing differences.

In addition to extending existing research to different hierarchical levels of linguistic skill, the present study is based on a relatively unstudied language pair in this context, L1 Spanish and L2 English[1]. Nearly all of the research on immersion education discussed above was done in Canada and focuses on English as the home language and French as the medium of instruction. It is currently unclear whether the results can be generalized across school systems and language pairs. As mentioned before, successful performance on L1 literacy skills in absence of explicit instruction depends on the extent of within- and between-language transfer, which may differ across languages and language pairs. For example, a study investigating L1-Spanish L2-English children observed cross-linguistic transfer of morphological awareness to reading from Spanish to English, but not from English to Spanish (Ramirez et al., 2010). Note that Spanish, the native language of our participants, has a much more transparent orthography, with a clear grapheme-to-morpheme conversion, and more complex morphology than English, the language of instruction. As a consequence of its opacity, reading acquisition proceeds at a slower rate in English, the least transparent of the alphabetic languages, compared to more transparent languages (Bruck, Genesee, & Caravolas,

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[1] Although some very interesting research has been carried out with L1-Spanish speakers in the United States who were immersed in their second language, English, at school, by attending either fulltime English instruction or two-way Spanish-English immersion education (Oller & Eilers, 2002), these studies are based on different contextual conditions: with the language of schooling being the majority language, immersion students were already bilingual at school entry and mostly came from bilingual homes. Their L2 was compared to monolinguals' L1.

1997; Frith, Wimmer, & Landerl, 1998; Goswami, Gombert, & de Barrera, 1998; Goswami, Ziegler, Dalton, & Schneider, 2001, Seymour, Aro, & Erskine, 2003; for a review, see Ziegler & Goswami, 2005). The constellation for L1-English and French immersion is different, with French having the relatively more transparent orthography and richer morphology. Such differences might further determine the effects of immersion schooling in the specific case of L1-Spanish L2-English.

There are two nested research questions:

1. Do L1-Spanish children enrolled in an L2-English immersion program differ from their monolingual Spanish age peers in terms of L1 text-level reading comprehension?
2. Are there any between-group differences in terms of selected skills and abilities that are known to contribute to reading comprehension, including listening comprehension, vocabulary knowledge, phonological and morphological awareness, syntax, memory, rapid naming and visual word recognition?

Method

Participants

Participants were 144 children aged 7 through 14, divided into three different age groups: 50 seven to eight year olds [*M* = 7.44 (0.5), grade 2] 52 nine to ten year olds [*M* = 9.6 (0.5), grade 3 and 4], and 42 eleven to fourteen year olds [(*M* = 11.93 (0.9), grade 5 and 8][2]. All were native speakers of Spanish from monolingual homes in Granada, Spain. Seventy-two children were enrolled in an English immersion program where they had been since the first

[2] These age groups were selected because they correspond with important developmental stages in cognitive development, and in the trajectory of literacy acquisition. For reading comprehension in particular, individual and age- or grade related variation might differ according to developmental stage, hence the need for a finer-grained categorization in terms of age.

grade (emergent bilingual children, BL), the remaining 72 children had been attending a monolingual school (monolingual children, ML). Children in the immersion program received almost all schooling in English, apart from Spanish language and literature classes, and foreign language instruction in French (3h/week starting at age 10). For first and second graders (7-8 year olds), 18h per week were held in English, for third and fourth graders (9-10 year olds), 17h per week, for 5^{th}-8^{th} graders, 13h per week. In the monolingual program, all classes were held in L1-Spanish, with the exception of foreign language instruction in English (1^{st} through 4^{th} grade/7-10 year olds: 2h/week, 5^{th} through 8^{th} grade/11-14 year olds: 3h/week) and French (3h/week starting at age 10). Extracurricular and non-teaching hours made up 9.5h per week that were held in L2-English in the immersion program and in L1-Spanish in the monolingual program.

The sample was drawn from a large scale study on cognition and education. We identified the children from the English immersion program from the corresponding age groups that had participated in the tasks. From all monolingual programs, we first determined the one that matched the bilingual immersion program the closest on factors like socioeconomic status (SES), home literacy environment (HLE, the degree in which parents engage in, provide and/or encourage literacy-related activities in the home). Parental education level, assessed via family questionnaires served as an approximation to SES (Ensminger, Fothergill, Bornstein, & Bradley 2003). We asked for the fathers' and mothers' highest educational diploma obtained separately, distinguishing between university level (5), vocational training (4), high school (3), secondary/middle school (2) and elementary school (1). Home literacy environment was also assessed in questionnaire using items with 4 response categories (e. g.: "We encourage our child to read", response categories: 0-"never", 1-"sometimes", 2-"almost always", 3-"always").

Each bilingual child was then matched with a monolingual by randomly selecting one child from a group of monolinguals equated for age, grade level and sex. Children diagnosed with neuropsychological disorders or learning disabilities, as well as children who had been exposed to a language other than Spanish outside of school (e.g., children from bilingual families) were excluded from the sample a priori. Prior to testing, informed consent to children's participation was obtained from a parent or legal guardian.

The resulting two groups of children did not differ in maternal education level (overall: $\chi^2 LL$ (4) = 4.26, p >.10, 7-8 year olds: $\chi^2 LL$ (4) = 3.39, p >.10, 8-9 year olds: χ^2 LL (4) = 4.86, p >.10, 11-14 year olds: χ^2 LL (4) = 2.92, p >.10), paternal education level (overall: χ^2 LL (4) = 2.32, p >.10, 7-8 year olds: χ^2 LL (4) = 3.84, p >.10, 8-9 year olds: χ^2 LL (4) = 7.60, p >.10, 11-14 year olds: χ^2 LL (4) = 0.62, p >.10) or home literacy (overall: F (1, 142) = 3.04, p > .05, η_p^2=.02, 7-8 year olds: F (1, 48) = 1.54, p > .05, η_p^2=.03, 9-10 year olds: F (1, 50) = 0.97, p > .05, η_p^2=.02, 11-14 year olds: F (1, 40) = 0.57, p > .05, η_p^2=.01). See table 1 for measures of parental education and home literacy environment divided by school and age.

[Insert Table 1]

Procedure

All tasks were conducted in a school setting, in 4 sessions of 45 minutes duration each, and during regular school hours in a quiet room inside the school. Children were assessed individually. Data regarding socioeconomic status, family and language background, home literacy environment, as well as academic, psychological and neurological history were obtained in the form of questionnaires to be filled out by parents or guardians at home. Additional questionnaire data regarding academic performance and psychological or neurological conditions was collected from teachers during recess. Instructions read by a female native speaker of Spanish were presented auditorily through headphones. Instructions were repeated as many times as necessary to ensure children understood what they had to do. All instructions and task contents were presented in Spanish. Computerized tasks were presented using E-Prime 2.0 (Schneider, Eschman & Zuccolotto, 2002) or DMDX (Forster & Forster, 2003) software.

Tasks and scoring

Fluid and crystallized intelligence.

Fluid (nonverbal) and crystallized (verbal) intelligence were assessed using the Kaufman Brief Intelligence Test (K-BIT, Kaufman & Kaufman, 2004). We used the direct scores for both scales (direct scores range from 0-48 for the fluid intelligence and from 0-82 for the crystallized intelligence subscale).

Phonological awareness.

We used a phoneme deletion task, a measure of phonological awareness in school aged children (see McDougall, Hulme, Ellis & Monk, 1994). Children listened to individual words that were presented over headphones, and were asked to repeat the same word out loud omitting a certain phoneme. For example, a child might hear the word “nube” (engl.: “cloud”) and be asked to repeat the word without the “n”, in which case the correct answer would be “ube”. Participants’ responses were recorded and mean accuracy rates calculated to obtain a score per participant.

Lexical access and reading fluency.

Rapid automatic naming.

Participants are presented with an array of six recurring items (e.g., objects) in random order and are asked to name the entire sequence as fast as possible without making mistakes.

Rapid naming measures phonological access, lexical retrieval, and reading fluency in production (Bowers & Swanson, 1991; Wolf, 1986; Wolf & Bowers, 1999) and is less influenced by vocabulary knowledge than discreet naming, where a much larger number of items per category is used. Participants' scores consist of naming times for the complete array in seconds, averaged across the objects and letters categories.

Lexical decision task.

In the lexical decision task, participants read Spanish words as well as strings of letters that follow the phonotactic rules of the Spanish language but do not form an existing word. Participants are instructed to press one of two buttons to indicate whether the presented letter string is a Spanish word ("yes" response) or a nonword ("no" response). The lexical decision task measures lexical access and reading fluency in comprehension. For this task, we calculated mean reaction times for words to measure the speed of lexical access.

Orthographic skill.

Children were presented with two letter strings and had to indicate by pressing a button whether they both were the same. Stimuli contained identical pairs, as well as pairs where one letter string was a word and the other one contained the same letters, but some of them in transposed position (e.g. "casino" vs. "CANISO"). For each participant, a score for the transposed-letter effect was calculated: accuracy rate for identical pairs minus accuracy rates for transposed letter pairs (see Duñabeitia, Orihuela, & Carreiras, 2014, for a similar task).

Morphological awareness.

The task was similar to the one used by Barber and Carreiras (2005). Participants were presented with sentences that were either grammatically correct (10 sentences) or contained a gender or number violation (10 sentences each). All sentences contained an adjective in predicative position following a noun, and violations are always implemented in the adjective. In Spanish, adjectives and nouns are marked for gender and number and must therefore be consistent in this type of sentence. Condition was counterbalanced across participants, and lexical frequency, number of letters, and number of syllables of target adjectives were controlled for each condition (correct, gender-inconsistent, number-inconsistent). See Table 2 for examples of the 4 different conditions. Participants were asked to indicate by pressing a button whether the present sentence was correct or not, scores were calculated as accuracy rates averaged across sentences containing gender and number violations, and corrected by error rates for correct sentences.

[Insert Table 2]

Sentence comprehension.

Sentence-level comprehension was measured by means of a picture-sentence matching task. Materials were adapted from the syntax scale of the PROLEC-R test battery for reading processes in Spanish (Cuetos, Rodríguez, Ruano, & Arribas, 2007). Sentences were presented in written form on the computer screen, alongside with 4 pictures from which children had to select the one representing the sentence. Sentence types differed in complexity: attributive and simple active structures, active sentences containing a negation, passive structures, sentences containing a focalized object, a split subject, a split object, a subject-subordinate clause or an object-subordinate clause. After assessing difficulty empirically, we averaged accuracy rates across the most difficult sentence types, namely passive sentences, sentences containing a focalized or a split object, and sentences containing an object-subordinate clause. See Table 3 for examples of each of the averaged (difficult) sentence types. This task measures the ability to interpret sentence meaning despite increased difficulty due to noncanonical order, or increased working memory load due to the need to maintain a syntagma active while reading the rest of the sentence (e.g., Montgomery, Magimairaj, & O'Malley, 2008).

[Insert Table 3]

Long-term memory (LTM).

To measure long-term episodic memory, a sentence recognition task was created where children were presented with short texts that consisted of two sentences describing events, and one describing a state, for example, *The car crashed into the bus* (event), *the bus was near the crossroads* (stative), *the car skidded on the ice* (event). Texts were presented auditorily over headphones. At the beginning of the task the participants received a block of 4 stories over, sentence-by-sentence. Each story was separated with a long pause. After finishing the four stories, participants carried out a recognition test in which four sentences were presented for each story (16 sentences total). There were always two sentences that had been presented in the preceding text passage (original sentences), and two foil sentences. Of the foil sentences, one was semantically congruent with the story (*the car was near the crossroads*), another one was incongruent (*the bus skidded on the ice*). The set of 16 recognition sentences (4 for each story) was presented together in the same block, with the order of presentation randomized. The participants were instructed to decide if they thought they had literally read the sentence before and indicate their response by pressing a designated "yes" and "no" button. After finishing the task, the participants received a new block of 4 stories and 16 recognition sentences. Block order was counterbalanced across participants. Percentage scores for accuracy ("yes"-responses to original sentences) and false alarms ("yes"-responses to semantically congruent foil sentences) were calculated, and false alarm rates subtracted from accuracy rates.

Working memory (WM).

To assess verbal working memory, we used a Spanish version of the Daneman and Carpenter's (1980) reading span task that had been adapted for children (García-Madruga et al., 2013). We followed the García-Madruga and colleagues' (2013) scoring procedure, which yields a single digit number between 2 and 6, reflecting participants' reading span.

Reading comprehension.

Materials consisted of 8 texts that differed in difficulty (4 easy, 4 difficult texts) as well as text type (2 narrative and 2 expository texts within each level of difficulty). Participants were presented with 4 texts (1easy-narrative, 1 easy-expository, 1 difficult-narrative, 1 difficult-expository). Children read texts on the computer screen at their own reading pace. Upon completion of each text, 4 questions with 2 answer alternatives (true/false) each were presented on the computer screen to evaluate comprehension and children were instructed to indicate their response by pressing a corresponding button. Questions included literal as well as inferential questions. Correct answer (true/false) and text order were counterbalanced across participants. Accuracy rates for each participant were calculated.

Results

Principal component analysis.

In a first step of analysis, scores from all component tasks (K-BIT fluid and crystallized intelligence, rapid naming, lexical decision task, phonological and morphological awareness, orthographic skill, reading span, LTM and sentence comprehension scores) were submitted to a principal component analysis (PCA) with varimax rotation to reduce data and identify patterns in the component tasks. The value for the Kaiser-Meyer-Olkin criterium (KMO) was .87, and Bartlett's test for sphericity was significant (p <.001), justifying the use of PCA as a means of data reduction. It is important to note that contrary to Factor Analysis, PCA does not assume that individual tasks and measures loading highly on a component are interchangeable indicators of the same latent construct, and the extracted components cannot be interpreted as such. Rather, PCA is a means of data reduction where principal components represent a linear combination of a larger number of underlying variables into fewer dimensions while retaining as much overall variance as possible (e.g., Eid, Gollwitzer, & Schmitt, 2010). PCA is conducive to the aims of this study and is appropriate given the multifaceted nature of our task battery. The use of an orthogonal rotation method - resulting in non-correlated components – was based on our interest in identifying independent sources of variability in our data and often leads to more interpretable solutions.

Two components with eigenvalues above 1.00 were extracted[3]. The appropriate number of components was additionally confirmed through visual inspection of the scree plot. The components accounted for 31 (component 1) and 24 (component 2) percent of overall variance, respectively (rotated solution). Factor loadings on the rotated solution are represented in Figure 1. Reaction times for rapid naming and lexical decision, phonological and orthographic processing, as well as morphological awareness loaded on component 1 (factor loadings between |.54| and |.76|). This component was named *Linguistic processing*. Sentence comprehension, long-term memory, and fluid intelligence loaded on component 2 (factor loadings between .69 and .74); this component was interpreted as reflecting *Memory and Reasoning*. Two variables, namely WM and crystallized intelligence had substantial factor loadings (above .4) on both components.

[Insert Figure 1]

[3] Similar two-factor solutions were obtained for separate analyses by language status.

Analysis of variance (ANOVAs). Alpha-levels were set to zero and were controlled using the Holm-Bonferroni method (Holm, 1979).

Linguistic processing and Memory & Reasoning.

We carried out two separate 3 x 2 ANOVAs with age (7-8 year olds, 9-10 year olds, 11-14 year olds) and bilingual status (BL vs. ML) as independent variables on extracted factor scores. ANOVAs revealed main effects of age for both components (Linguistic processing: F (2, 138) = 33.95, p <.001, η_p^2= .34, Memory & Reasoning, F (2, 138) = 21.24, p <.001, η_p^2= .24). There were significant linear trends for both components (Linguistic processing: F (1, 88) = 79.81, p < .001, η_p^2 = .48, Memory & Reasoning: F (1, 88) = 35.18, p < .001, η_p^2 = .29), indicating that older children scored higher than younger ones (Linguistic processing in 7-8 yr. olds, M = 2.21, SE = 0.14, in 11-14 yr. olds, M = 3.67, SE = 0.1, Memory & Language in 7-8 yr. olds, M = 2.45, SE = 0.12, in 11-14 yr. olds, M = 3.6, SE = 0.13).

Monolingual children outperformed emergent bilingual children on Linguistic processing, F (1,138) = 16.41, p <.001, η_p^2= .11 (monolinguals, M = 3.27, SE = 0.1, emergent bilinguals, M = 2.77, SE = 0.13), while bilinguals scored higher on the Memory & Reasoning component, F (1, 138) = 4.55, p <.05, η_p^2= .03 (monolinguals, M = 2.84, SE = 0.13, emergent bilinguals, M = 3.2, SE = 0.1). Interactions between age and bilingual status did not reach significance for either component (Fs < 0.68, ps >.10, η_p^2 <.01). Performance for monolingual vs. emergent bilingual children across age is depicted in Figures 2 and 3[4]. Descriptive values and inference statistics for the effect of bilingual status on individual component tasks are represented in Table 4. Most notable, significant main effects were observed for reaction

[4] Since extracted factor scores were centered around zero, we carried out a linear transformation for illustration purposes, whereby the absolute value of the minimum out of all extracted values [Min $_{\text{linguistic processing}}$ = -3.02] was added to each individual factor score.

times on the rapid naming and lexical decision tasks as well as morphological awareness (along with a marginally significant effect for phonological awareness), where monolinguals showed better performance. Emergent bilinguals showed a tendency towards increased LTM.

[Insert Figure 2]

[Insert Figure 3]

[Insert Table 4]

Reading comprehension.

We conducted a 3 x 2 x 2 mixed ANOVA on reading comprehension scores. Scores were collapsed across text type (narrative vs expository), as there were no significant differences, F (1, 138) = 1.89, p >. 05, η_p^2 = .01. Analyses thus included one within-subjects variable, difficulty, with two levels (easy vs. difficult), and two between-group variables, namely, age, with three levels (7-8 year olds, 9-10 year olds, 11-14 year olds), and bilingual status (BL vs. ML). There was a significant effect of difficulty, F (1, 138) = 183.66, $p < .001$, $\eta_p^2 = .57$, with accuracy rates being lower for difficult texts (M = 52.95, SE = 2.06) than for easy texts (M = 75.26, SE = 1.81), as well as age, F (2, 138) = 18.55, $p < .001$, η_p^2 =.21, with older children (M = 78.57, SE = 2.64) outperforming younger ones (M = 55.38, SE = 2.76) as evidenced by a significant linear trend, F (1, 88) = 36.61, $p < .001$, η_p^2 =.29. There was no main effect of bilingual status, F (1, 138) = 0.23, $p > .10$, $\eta_p^2 < .01$, as emergent bilingual and monolingual children showed a similar level of overall performance (monolinguals, M = 64.58, SE = 2.5, emergent bilinguals, M = 63.63, SE = 2.48). None of the interactions were significant (all $Fs \leq 1.79$, ps >.10 and $\eta_p^2 s \leq .03$). See Figure 4 for illustration.

[Insert Figure 4]

Regression analyses.

Linear regression with reading comprehension scores as dependent variable and Linguistic processing and Memory & Reasoning as predictors were carried out in order to determine to which extent both components contribute to reading comprehension at the text-level. Based on the entire sample, both components explained significant variance (Memory & Reasoning, $b = 7.68$, $t = 4.66$, $p < .001$, $\Delta R^2 = .13$, Linguistic processing, $b = 6.81$, $t = 4.01$, $p < .001$, $\Delta R^2 = .11$). Separate regression analyses by language status revealed differential contributions of both factors for bilingual vs. monolingual children. In bilingual children, more variance was explained by Linguistic processing, $b = 7.97$, $t = 3.49$, $p = .001$, $\Delta R^2 = .13$, while the predictive effect of Memory & Reasoning was marginally significant, $b = 5.15$, $t = 1.87$, $p = .07$, $\Delta R^2 = .05$. In monolinguals, on the other hand, the amount of variance explained was larger for Memory & Reasoning, $b = 9.91$, $t = 4.88$, $p < .001$, $\Delta R^2 = .25$, compared to Linguistic processing, $b = 7.18$, $t = 2.73$, $p = .008$, $\Delta R^2 = .10$. Figure 5 illustrates the relationship between each factor and reading comprehension within both groups.

[Insert Figure 5]

Discussion

The present article investigates the costs and benefits of monolingual vs. L2 immersion education for reading comprehension. Our design allows us to integrate developmental, educational and cognitive approaches, as text-level reading comprehension is a complex cognitive skill composed by a number of underlying component skills and taught as part of school curricula. To this end, we assessed L1-Spanish children enrolled in an L2-English immersion program and monolingual Spanish age peers at different developmental stages in L1 text comprehension and a number of related skills (vocabulary, lexical access in production and comprehension, phonological and morphological abilities, verbal Working

Memory and Long-term Memory, and sentence-level syntactic comprehension). English immersion education has been increasingly implemented in the Spanish school system and will continue to do so throughout the next years, making questions regarding the consequences particularly relevant. L2 immersion students receive less explicit instruction in L1 literacy skills than monolinguals and unlike these, divide their linguistic exposure between two languages. In addition, current cognitive-linguistic theories recognize that bilinguals activate both languages in parallel, leading to increased cognitive load and slower lexical access when processing within-language, compared to monolinguals (e.g., Green, 1998). From this theoretical perspective, a potential concern is that L2 immersion education might present a certain drawback or increased vulnerability for L1 development and literacy acquisition.

Analyses revealed that overall, emergent bilinguals did not differ from their monolingual counterparts in terms of L1 text-level reading comprehension. All children improved their L1 reading skills with age at a similar pace, regardless of the language of formal instruction. Interestingly, even though both groups performed similarly on text-reading comprehension, they differed in selected skills and abilities that are known to contribute to reading comprehension.

The principal component analysis (PCA) allowed us to categorize subskills underlying reading comprehension into two broader components. The first component, which we named “Linguistic processing”, is mostly based on reaction times for rapid naming and lexical decision, phonological and orthographic processing, as well as morphological awareness. These measures require processing and attending to the lexical and sublexical units that form the basis of written text (for example, the speed or fluency of lexical access from written words vs. pictures). Sentence comprehension, long-term memory, and fluid intelligence loaded on the second component, which we refer to as “Memory & Reasoning”. Sentence comprehension, especially for complex and noncanonical sentences, reflects computation and integration processes in long-term working memory (Kidd, 2013; Boyle, Lindell, & Kidd, 2013; Lewis, Vasishth, & Van Dyke, 2008; Montgomery et al., 2008). Two measures, Working Memory and crystallized intelligence, had high factor loadings on both components. High loadings of the same task on multiple principal components can sometimes complicate interpretation, but in this case can be easily explained. The crystallized intelligence scale of the K-BIT consists of a vocabulary test; as a measure of lexical knowledge and semantic memory in the language domain, it should load on both components. Similarly, reading span is a measure of Working Memory with its executive component, but also draws heavily on time-limited language-based processing (Towse, Hitch & Hutton, 1998). Apart from fluid intelligence, the measures loading highly on the second component thus capture different aspects of memory. Overall, the Memory & Reasoning component reflects aptitude and ability to learn and retain new information, which in reading comprehension are needed to infer information from text, construct and maintain a mental representation (see Oakhill, Cain, & Bryant, 2003, for a discussion of different components of reading comprehension). Since both components are orthogonal, thus sharing no variance, the PCA allows us to separate these two aspects of reading comprehension. In sum, the resulting components align with theoretical models of reading comprehension that describe two important classes of underlying component factors: on the one hand, purely linguistic processes and abilities whose effects are often mediated via lexical reading skill (such as phonological or orthographic skills), and on the other hand, cognitive abilities that are not necessarily tied to a specific domain (such as working memory or inference making, e.g., Oakhill et al., 2003). Thus, the resulting structure captures these theoretical components and extends them to bilingual reading.

Although monolinguals and bilinguals obtained similar scores in the reading task, they differed in terms of the two components. Thus, monolingual children outperformed emergent bilingual children on Linguistic processing, while bilinguals scored higher on the Memory & Reasoning component. The lower scores in L1 skills obtained by children undergoing L2 immersion replicate previous findings, and probably reflect (i) the reduced exposure to formal instruction and (ii) the need to cope with language co-activation. A closer look at the group differences in the specific skills that form the linguistic component supports this idea. Thus, monolinguals surpassed emergent bilinguals in rapid naming and lexical decision speed. Slower lexical access is often found in bilinguals (e.g., Ivanova & Costa, 2008; Michael & Gollan, 2005; Yan & Nicoladis, 2009) and has been associated with the fact that bilinguals activate their two languages in parallel (Poarch & van Hell, 2012; Thierry & Wu, 2007). Language co-activation forces bilinguals to negotiate the attentional demands of both languages and avoid intrusions from the unintended language. Most theories agree that this process involves inhibiting or otherwise reducing the activation of the non-target language, leading to slower naming times (e.g., Costa, La Heij, & Navarrete, 2006; Green, 1998). Here, we observe an effect on children's continuously dominant L1. This finding is in line with Linck, Kroll, and Sunderman (2009), who report a relative slowdown of L1 verbal processing in university students immersed in an L2 during a study abroad program, but to our knowledge, this kind of effect has not yet been reported in regards to L2 immersion students.

Also among the tasks that loaded highly on the linguistic component, and unlike other studies (e.g., Bialystok, Peets, & Moreno, 2014), we did not find any enhancement of metalinguistic skills in emergent bilinguals, but an advantage for monolinguals in morphological awareness. This unexpected result could be due to the specific language combination in our study. From a theoretical viewpoint, metalinguistic advantages in bilingual children can be explained as due to the fact that between-language differences draw children's attention to the rules and regularities of a language and aid their understanding of the separation of form and content (e.g., Cummins, 1978, see also Marinova-Todd, 2012). However, most of the existing research evaluated immersed bilinguals in an L2 (French) with a richer morphology than their L1 (English). In contrast, the language of formal instruction of our bilingual sample (L2-English) is morphologically simpler than the L1, Spanish: modern English does not possess grammatical gender, nor does it require plural marking for adjectives. In fact, as illustrated by the example above, the gender and number violations in Spanish implemented in the morphological awareness task have no English equivalents. This might explain why in this case, the experience with a second language did not yield immersion children an advantage in morphological awareness, and why the latter might, in fact, be better acquired by monolinguals with higher exposure to the L1 in formal education. This result highlights the necessity to account for language pairs when evaluating linguistic (or metalinguistic) skills. Overall, the greater difficulties emergent bilinguals experience in processing L1 lexical and sublexical forms likely reflects exposure effects (Oller & Eilers, 2002) in addition to increased cognitive load resulting from language co-activation.

Regarding the second component, our results indicate that emergent bilinguals outperformed monolinguals on the Memory & Reasoning component. Memory capacity has been less central in the literature on the consequences of bilingualism and it therefore remains to be seen whether this finding extends across different samples of bilinguals or immersion students. For Working Memory, previous results have been mixed, although a bilingual advantage has sometimes been observed, especially when executive demands are high (Morales, Calvo, & Bialystok, 2013) and linguistic deficits are taken into account (Blom, Küntay, Messer, Verhagen, & Leseman, 2014). This might explain why in our data, a bilingual advantage emerged for principal component scores, but not for individual task scores. On the other hand, there has been one report of increased associative memory in young adults after having undergone an intensive L2 immersion program (Mårtensson & Lövdén, 2011), supporting the idea that highly demanding language-learning environments not only rely on memory skills, but also modulate and enhance them.

Importantly, the poorer performance of bilinguals in the linguistic component skills did not result in reduced performance on text-level comprehension compared to monolingual controls. This is particularly remarkable given the result of the regression analyses. Individual differences in reading comprehension by language status (bilinguals vs. monolinguals) were predicted to a larger extent by the component in which the respective group showed greater difficulties: Linguistic processing for bilinguals and Memory & Reasoning for monolinguals. This finding is intriguing: on the one hand, the pattern observed for emergent bilingual children resembles one that is more typical for younger children, characterizing them as less experienced L1 readers. Typically, within the earlier grades of elementary school, individual differences in reading comprehension depend mainly on lower-level linguistic (e.g., lexical, orthographic and phonological) abilities whereas in older children, it is mostly higher-level, conceptual processes that determine outcome differences (e.g. Diakidoy et al., 2005, Tilstra et al., 2009). On the other hand, the reading comprehension of emergent bilingual children did not lag behind their monolingual peers, and as previously mentioned, they excelled on the Memory & Reasoning component, indicating a high level of cognitive ability and capacity that would not be present in younger readers. Thus, the cognitive advantage in Memory & Reasoning abilities in the bilingual groups may have helped them to compensate for deficits in Linguistic processing. In addition, the fact that less overall variance in reading comprehension scores was accounted for by the two principal components in the bilingual group suggests that linguistic deficits in emergent bilinguals might be compensated via multiple processes, some of which are not captured by the 2-component structure (for example, more purely executive, non-linguistic processes, or more complex conceptual processes not measured here).

In summary, the present study contributes to the existing literature in a several aspects. First, we approached the study of reading comprehension from a hierarchical perspective, evaluating children on the complex skill level as well as on underlying cognitive and linguistic components, represented by two principal components. Virtually all tasks that are currently available to assess cognitive development and performance behaviorally reflect multiple processes, which poses a challenge to research on the cognitive consequences of bilingual development and education: selective effects are often difficult to localize. Using principal component analysis on our task battery made it possible to identify distinct sources of variance within the same tasks that are associated with opposing outcome patterns and that would not have been dissociable otherwise (see also Engel de Abreu, 2011, for a similar application of PCA). On the other hand, it has been mostly basic cognitive processes that have been reported to be subject to the effects of bilingualism, which is informative on a theoretical level but leaves open questions regarding the practical relevance. Linking the level of basic processes to complex skill by virtue of a cognitive components perspective might be a way to build on existent evidence to gradually increase ecological validity of research findings. Likewise, this approach can be transferred to alternative group and/or individual differences in the acquisition of reading comprehension and might also apply to other complex skills such as mathematics.

Secondly, we extend the existing research on immersion education. Previous research into the academic and cognitive outcomes of L2 immersion schooling has largely been limited to the Canadian system, with L1 English as the home language and L2 French as the school language. The current study is based on a relatively unstudied language pair in this context: L1-Spanish and L2-English. L2 immersion education poses a unique path to bilingualism, and in this sense, this research also extends some of the findings from early and more balanced bilinguals. In this regard, an advantage of studying immersion education is that both groups of children had comparable socioeconomic statuses and shared the same cultural background, and unlike in many previous studies, neither bilinguals nor monolinguals were immigrants. These two aspects have been claimed as a source of variability in bilingual studies (e.g., Morton & Harper, 2007), which is reduced here. Unfortunately, as bilingual status, and in this case, choice of school, cannot be randomly assigned, this does not preclude the possibility that there might be between-group differences beyond L2 immersion experience. Further longitudinal research might help to clarify to what extent pertinent effects depend on pre-existent group differences. Thirdly, our results suggest that the equivalent performance on a specific complex activity such as reading comprehension is modulated by differential capacities in the specific skills necessary to succeed. Thus, even when particular linguistic skills seem to be delayed by L2 immersion schooling, other processes appear to compensate so bilingual children achieve monolingual-like performance on text-level comprehension. This finding encourages a positive outlook on the flexibility of literacy acquisition in general. The presence of compensation effects in light of selective costs and benefits in different populations suggests that readers with different learning histories and from different language backgrounds are able to draw from individual resources to compensate areas of deficit, at least as regards typically developing children. To the extent that these findings can be generalized to special needs populations these outcomes can also inform intervention studies in reading, and, specifically, add support for resource- rather than deficit-oriented intervention strategies. Future studies should further investigate non-linguistic components, as well as more specific text inference and integration skills that contribute to the development of reading comprehension.

In conclusion, L2 immersion education does not have any detrimental consequences for the development of text reading comprehension on the native language of Spanish children enrolled in English immersion schools. As for an educational viewpoint, children enrolled in immersion programs showed similar skills in L1 reading comprehension as monolinguals. Receiving formal instruction in a second language was associated with decreased performance on specific language skills such as rapid naming, lexical decision and morphological awareness. In exchange, emergent bilinguals showed better Memory & Reasoning skills, which seem to compensate for linguistic deficits in reading comprehension. In terms of its methodological contributions, our findings highlight the need to carefully consider task selectivity as well as participant characteristics, such as the “type” of bilingualism or language combination, and point a way to deal with problems of task impurity through statistical analyses.

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Figure Captions

Figure 1. Factor loadings for component tasks [on the left: rapid automatic naming, lexical decision, phonological awareness (“phonological”; phoneme deletion), orthographic skill (“orthographic”; transposed letter), working memory (“WM”, reading span), long-term memory (“LTM”), crystallized and fluid intelligence, and sentence comprehension, scores as described in the methods section] on components 1 and 2 (on the right) extracted via principal component analysis. Low factor loadings (<.4) are suppressed.

Figure 2. Linguistic processing (component 1) in emergent bilingual (BL) vs. monolingual children (ML) across age groups. The y-axis represents transformed factor scores of component 1. Error bars represent the standard error of the mean.

Figure 3. Memory & Reasoning (component 2) in emergent bilingual (BL) vs. monolingual children (ML) across age groups. The y-axis represents transformed factor scores of component 2. Error bars represent the standard error of the mean.

Figure 4. Reading comprehension in emergent bilingual (BL) vs. monolingual children (ML) across age groups.

Figure 5. Reading comprehension in function of scores for a) Linguistic processing and b) Memory & Reasoning for emergent bilingual and monolingual children.