Real time comprehension of Spanish prepositions and prepositional locutions in bilingual children with Developmental Language Disorder: a study based on eye movement evidence

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Abstract

Purpose: In the present study we examine the capacity of bilingual children with Developmental Language Disorder (DLD) to comprehend different Spanish prepositions and prepositional locutions in a simple sentence structure; for example, *El gato está sobre la mesa/El gato está bajo la mesa* (The cat is on the table/The cat is under the table). Function words, and more specifically prepositions and prepositional locutions, are considered to be one of the most important difficulties in the linguistic production of children with the aforementioned disorder. **Method**: We use simple sentence structures to reduce lexical difficulties, in order to focus our evaluation strictly on the grammatical morphemes under study. Ninety-six Spanish and Catalan-speaking participants, divided into four groups, were evaluated in an eye-tracking psycholinguistic experiment: 24 children with DLD (average age 7.8), 24 children with the same chronological age (average age 7.8), 24 children with the same linguistic level (average age 6.8) and 24 adults (average age 22.5). **Results**: The empirical data show that, despite some differences, children with DLD and children without language impairment can comprehend prepositions and prepositional locutions under the current experimental conditions. **Conclusion**: Our results suggest that children with DLD's capacity to comprehend prepositions and prepositional locutions of the Spanish language, in real time and within simple sentence structures, is preserved.

Keywords

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Introduction

Problems with grammatical morphology are characteristic of children with DLD, according to empirical literature. Leonard (2014), in a wide review, argues that many of the hypotheses regarding the nature of Developmental Language Disorder (DLD) focus their interest on grammar, because morphosyntactic problems in DLD are noteworthy. In a similar approach, Mendoza (2012) states that the most severe difficulties in DLD are found in the production and comprehension of grammatical morphemes. In more detail, psycholinguistic research has mostly focused on the use of verbal morphology (Bishop, 1997; Conti-Ramsden and Jones 1997; Grinstead, De la Mora, Pratt and Flores, 2009; Hoover, Storkel, and Rice, 2012; Leonard, Eyer, Bedore, and Grela, 1997; Sanz-Torrent, Serrat, Andreu, Serra, 2008) and the use of function words (Aguilar, Sanz-Torrent, and Serra, 2007; Auza and Morgan, 2013a, 2013b; Bedore and Leonard, 2001, 2005; Grela, Rashiti and Soares, 2004).

Auza (2009) and Auza and Morgan (2013a, 2013b) suggest that the problems with grammatical morphology in children with DLD vary according to the characteristics of specific languages. Under their perspective, Romance languages show evidence of fragility in the use of prepositions, articles, and clitic pronouns. Empirical research has, to a greater extent, dealt with some of these grammatical morphemes rather than with others, i.e., there is more research on clitic pronouns (Jacobson and Schwartz, 2002; Morgan, Restrepo and Auza, 2013; Restrepo and Gutiérrez-Clellen, 2001; Theodorou and Grohmann, 2015; Tuller, Delage, Monjauze, Piller and Barthez, 2011) and articles (Auza and Morgan, 2013a; Bedore and Leonard, 2001, 2005; Bosch and Serra, 1997; Chondrogianni and Marinis, 2015; Leonard, Bortolini, Caselli, McGregor and Sabbadini, 1992; Polite, Leonard and Roberts, 2011), than on prepositions.

Regarding prepositions, the few existing empirical studies generally indicate a significant effect on the production of these grammatical morphemes in children with DLD (Auza and Morgan, 2013b; Grela, Rashiti and Soares, 2004; Puglisi, Befi-Lopes and Takiuchi, 2005; Sanz-Torrent, Badia and Serra, 2008). However, there is a discrepancy as to which is the most problematic issue in their linguistic production of prepositions, since some studies point towards omission (Auza and Morgan, 2013b; Sanz-Torrent, Badia and Serra, 2008) and others towards substitution (Grela, Rashiti and Soares, 2004; Puglisi, Befi-Lopes and Takiuchi, 2005). For example, in the Study of Grela, Rashiti and Soares (2004), the dative preposition "to" was substituted with "at", "with" and "for". In the case of the preposition "on", the substitutions occurred with the prepositions "in" and "to"; and with the preposition "in", the substitutions were with "on", "up", and "at". However, some studies point to a consolidation of prepositions in DLD, especially in the ability of children with DLD to understand them (Puglisi, Befi-Lopes and Takiuchi, 2005; Watkins and Rice 1991).

Inquiring further, Grela, Rashiti and Soares (2004) evaluated the ability of English-speaking children with DLD to produce the locative prepositions "in" and "on" (as in "Put in the box" and "Put on the table") and the dative preposition "to" ("Give it to her"). The results of the study confirmed the initial hypothesis, which stated that children with DLD would make more mistakes than the children in the control groups. The errors that the children with DLD made (substitution of dative prepositions) allowed the authors to suggest a problem in the semantic function of prepositions, rather than in their syntactic function. Sanz-Torrent, Badia, and Serra (2008) analyzed the language of bilingual (Spanish and Catalan-speaking) children with DLD in order to establish error patterns in their language expression. One of the most frequent errors was omission related to different grammatical morphemes (prepositions, determiners,

pronouns, etc.). Specifically, prepositions were the most omitted morphemes by children with DLD, whose production was significantly lower than the production of children in a chronological control group, and similar to the production of a linguistic control group. Along a similar line, Auza and Morgan (2013b) analyzed errors in the production of prepositions by Spanish-speaking children with DLD. Thus, they evaluated the proper use of seven Spanish prepositions (SP: "a", "con", "de", "en", "hacia", "hasta" y "para") / (EN: "to", "with", "from/to/of", "in/on", "towards", "until", and "for") in a story retelling task with graphical representations. They found differences in the overall production of prepositions in comparison to that of control groups, with a significantly greater number of omissions. The greatest problem was found in monosyllabic and unstressed prepositions ("a", "en" and "con") / ("to", "in/on" and "with"). From the authors' perspective, these characteristics may be responsible for the difficulty recorded. Additionally, children with DLD would require more time when learning and mastering the different functions fulfilled by prepositions.

According to Grela, Rashiti and Soares (2004) grammatical morphemes (articles, pronouns, and prepositions) usually assume a syntactic function in the connection of different phrasal elements. Leonard (2014) recognizes that, in the case of grammatical morphemes -such as prepositions- syntactic knowledge is essentially required, but that semantic knowledge also plays a role in the difficulty of acquiring and using them. In this sense, the polysemy of prepositions is based on the fact that a single preposition, according to its sentence function, can establish one meaning or another. The difficulties observed in the production of prepositions by children with DLD may be explained by the surface hypothesis (Leonard, 1989, 2014). This hypothesis suggests that children with DLD have a greater difficulty with those grammatical elements that have a shorter duration and are phonologically less salient. On the other hand, Evans,

Saffran and Robe-Torres (2009) suggest that the difficulty with these kinds of grammatical morphemes is not due to a lack in their perception, but rather caused by a greater cognitive effort made by children with DLD related to their fragile and ineffective use of an implicit learning mechanism.

On the other hand, it would be important to mention that results of crosslinguistic studies in children with DLD (Bedore and Leonard, 2001, 2005; Leonard, 2014; Leonard, Sabbadini, Leonard and Volterra, 1987; Leonard, Sabbadini, Volterra and Leonard, 1988) have also led to the proposal of the morphological richness account. Under this theoretical perspective, children with DLD who acquire a morphologically rich language use grammatical morphemes more accurately than children with DLD who acquire a language with poor morphemes. Along the same lines, Mendoza (2012, 2016) argues that, as Spanish is a morphologically rich language, it is worth considering the possibility that Spanish-speaking children with DLD may present a greater capacity to use morphemes compared to other children who speak morphologically poorer languages.

According to the psycholinguistic literature, children with DLD tend to perform better in comprehension than in production tasks (Andreu, Sanz-Torrent and Rodriguez-Ferreiro, 2016; Castro-Rebolledo, Giraldo-Prieto, Hincapie-Haenao, Lopera and Pineda, 2004; Dale, Price, Bishop and Plomin, 2003; Puglisi, Befi-Lopes and Takiuchi, 2005). Additionally, Leonard (2014) also supports the idea that Spanish-speaking children with DLD have better skills in language comprehension, compared to language production. The explanation for the better performance in the comprehension tasks compared to the production ones may be that, although both types of tasks require semantic and syntactic processing, production tasks require a more sophisticated linguistic processing capability that is expressed in the dynamics of creating new sentences (Bishop, 1992).

The present study seeks to evaluate the online comprehension of prepositions and prepositional locutions within the margins of the "visual world paradigm" (Visual World Paradigm; Cooper, 1974; Tanenhaus, Spivey-Knowlton, Eberhard and Sedivy, 1995) through the methodology of eye tracking. This methodological paradigm offers the possibility to analyze the cognitive processing of linguistic elements within a sentence at the moment of the elements' occurrence. Thus, the fixation percentages (in every correct answer) for the experimental task provide valuable empirical information on a person's cognitive processing. According to Trueswell (2008), through the Eye Tracker tool it is relatively easy to get a detailed record of the way a participant looks around while listening to an audiovisual stimulus, which offers a description of their visual reference when facing reality (for further information on basic characteristics of eye-movements, see Rayner, 2009).

If we consider that grammatical morphemes guide the comprehension of a sentence, then a defective processing of prepositions and/or prepositional locutions will be reflected in the execution and in the glance pattern of the language comprehension register. Under this view, it would be expected that children with DLD will have a significantly lower comprehension compared to that of the control groups. If so, the possibility of a deficit in the comprehension of these linguistic grammatical morphemes and, consequently, of a more limited general linguistic comprehension, may be considered. Conversely, if the empirical data of children with DLD are similar to the data of children in the control groups, it will be possible to argue in favor of a less impaired comprehension of these grammatical morphemes than what is generally thought to exist. If children with DLD register levels of comprehension not significantly different from the control groups, the possibility of a greater capacity to process prepositions and prepositional locutions of the Spanish language could be proposed.

Methodology

Participants

Four experimental groups participated in this study: 24 children with DLD (age range 4.6-12, average age 7.8), 24 children in an Age control group (age range 4.6-12, average age 7.8), 24 children in a linguistic control group (based on Mean Length of Utterance by words, MLU-w, age range 4.3-9.4, average age 6.8), and finally, 24 adult university students (age range 18-30, average age 22.5). All participants in the study are simultaneous bilinguals of Spanish and Catalan that were equally exposed to both languages since birth, according to the parental report. In 2018, 52,7% of Barcelona citizens claimed that their initial language was Spanish and 31,5%, Catalan (Idescat, 2018). In the school system, there exists an immersion in/to Catalan in kindergarten. Later, in primary school, children receive two or three hours of Spanish, while the rest of the subjects are taught in Catalan (Arnau and Humbert, 1986; Strubell, 1996; Ferrer, 2000). According to Alarcón and Garzón (2011), children in Barcelona are equally proficient in both Spanish and Catalan, although the use of Spanish is more popular. For further information about Catalan and Spanish bilingualism and DLD, see Sanz-Torrent, Badia and Serra (2007), and Sanz-Torrent, Serrat, Andreu and Serra (2008).

Children with DLD were recruited from three different institutions: 1) UTAE (Unidad de Trastornos del Aprendizaje Escolar/Hospital Sant Joan de Déu, in English: Unit of School Learning Disorders/Hospital of Sant Joan de Déu); 2) CREDA Narcís Masó (Centro de Recursos Educativos para Deficiencias Auditivas, in English: Centre of Educational Resources for Hearing Impairments); and 3) ATELCA (Asociación del Trastorno Específico del Lenguaje de Cataluña, in English: Association of Specific Language Impairment of Catalonia). This research took place in 2013-4, and 2014-5, when the term SLI was the most prominently used, so the children were diagnosed with SLI by a speech-language therapist. However, we recognise that children who meet

these classic SLI criteria fall under the umbrella of DLD, so we decided to use this last term throughout the paper.

Materials

The DLD group and the control groups (AGE and MLU-w) were formed based on the results of the following standardized tests: The Kaufman Brief Intelligence Test (KBIT, Spanish version; Kaufman and Kaufman, 2004), the Peabody Picture Vocabulary Test—Third Edition (PPVT-III; Dunn, Dunn, and Arribas, 2006), and the Comprehension Test of Grammatical Structures (CEG; Mendoza, Carballo, Muñoz and Fresneda, 2006). All the children with DLD received a standard score of a nonverbal IQ of 85 or more on the matrices subtests of Kaufman Brief Intelligence Test (KBIT-MAT, Spanish version; Kaufman and Kaufman, 2004). Receptive and expressive vocabulary was assessed in all groups with the PPVT-III and the vocabulary subtest of Kaufman Brief Intelligence Test (KBIT-VOC), correspondingly. Grammatical abilities, on the other hand, were assessed with the Comprehension Test of Grammatical Structures (CEG; Mendoza, Carballo, Muñoz and Fresneda, 2006). This test is a Spanish adaptation of the Test for Reception of Grammar - Version 2 (TROG-2; Bishop, 2003) and measures the understanding of different grammatical contrasts. Finally, for the assessment of grammatical expressive complexity, the MLU-w value in words for each child was also calculated. The means of the tests used was 100 and the Standard Deviation (SD) was 15. For selection of the DLD group, the criteria, in the PPVT-III, the CEG, and the KBIT-VOC, was a score of at least a 1.25 standard deviation below the mean. As seen in Table 1 and 2, the DLD group showed statistical differences in all linguistic tests with respect to children from the Age control group. The descriptive data of the groups appear in Table 1 and 2.

[Insert Table 1 here]

[Insert Table 2 here]

In order to confirm the diagnosis of the DLD children, language samples were analyzed using the Spanish protocol for the Evaluation of Language Delay (AREL; Pérez and Serra, 1998). Language profiles based on transcripts of spontaneous speech provided information about the children's morphosyntactic abilities in language production, from which it was determined that they showed a delay of at least 1 year (see Bishop, 1997). In addition, anamnesis filled out by parents/caretakers also report functional limitations of the language disorder in academic terms, as well as in socio-emotional terms. This information was used to verify that children had no symptoms of impaired reciprocal social interaction.

For the selection of the children for the control groups, an evaluation of 260 children was conducted (age range between 3.9-12). The age-matched control group was equivalent in age (same year and ±2 months) to their counterparts in the DLD group. The MLU-w control group was equivalent in terms of linguistic level. Each child in the study group was paired with another child according to the MLU-w calculated in words (±0.5 words) and sex. As a result of the wide amplitude of the age range of the DLD group, two chronological subgroups were created: one for younger children (DLD 1: n=12 and average age 6.0) and one for older children (DLD 2: n=12, average age 9.7). This chronological classification was extrapolated to the rest of the control groups: Age Chronological Control Group (AGE1: average age 6.3 and AGE2: average age 9.4) and MLU-w Linguistic Control Group (MLU-w1: average age 5.4 y MLU-w2: average age 8.2). The research was approved by the Ethics Committee of the Universitat Oberta de Catalunya. Parents of the children with DLD as well as the adult participants signed a written consent for their participation in the study.

Stimuli

In total, 16 prepositions and 12 prepositional locutions were evaluated in 60 different simple-structure sentences (30 sentences in two different experimental lists: A and B. See List A in the Appendix C). A prepositional locution is a phrase that resembles a preposition in its syntactic behaviour or meaning (Bosque, 2010). The following prepositions were evaluated: Spanish: “a”, “ante”, “bajo”, “con”, “contra”, “de”, “desde”, “en”, “entre”, “hacia”, “hasta”, “para”, “por”, “sin”, “sobre”, “tras”; in English: “to”, “facing/before”, “under”, “with”, “against”, “from/to/of”, “since/from”, “in/on”, “between”, “towards”, “until”, “for”, “through”, “without”, “over/on”, “behind/after”. In the trials, the experimental task only tested the prototypical representation of each preposition. For example, in Figure 1, a stimulus of a preposition can be observed: "The cat is *on* the table" (Target: cat on the table, Competitor: cat under the table).

The following prepositional locutions were also evaluated: SP: “al lado de”, “alrededor de”, “cerca de”, “debajo de”, “delante de”, “dentro de”, “detrás de”, “encima de”, “en frente de”, “fuera de”, “junto a”, “lejos de”; EN: “next to”, “around the”, “close to”, “below of/under”, “in front of/opposite of”, “inside of”, “behind of”, “above of”, “in front of”, “outside of”, “next to”, “far from”. The fundamental criterion for the selection of the prepositions and the prepositional locutions was the possibility to represent them graphically. In this sense, prepositions like: SP: “durante” and “según”; EN: “during” and “according to” were discarded because of difficulty in representing them graphically. In Figure 2, a stimulus of a prepositional locution can be observed: "The bicycle is *in front of* the house" (Target: bicycle is in front of the house, Competitor: bicycle is behind the house).

[Insert Figure 1 here]

[Insert Figure 2 here]

In the case of prepositions, each stimulus contrasts a preposition either with its opposite or a different one ("The cat is *below/on* the table", "The girl walks *to/through* the park"). In each image, two elements appear in the form of distracters and have no direct relation with the preposition under study but contribute to the contextualization of the scene. The composition of the scene changes with respect to the nature of the preposition under study. In this sense, when studying a preposition of movement or direction (SP: "a", "de", "desde", "hacia", "hasta"/ EN: "to", "from/to", "since/from", "towards", "until") the image corresponding to the object of the preposition or prepositional locution appears twice (See Figure 3: "The bee flies *towards* the flower/ *from* the flower"). When we study a preposition of static representation (SP: "ante", "bajo", "con", "contra", "en", "entre", "para", "por", "sin", "sobre", "tras"; EN: "facing/before", "under", "with", "against", "in/on", "between", "for", "through", "without", "over/on", "behind/after"), the image corresponding to the subject of the sentence appears twice (See Figure 1: "The cat is *under/on* the table"). Finally, due to the complexity of the scene in some cases (SP: "entre", "para", "por", "hacia"; EN: "between", "for", "through", "towards"), images corresponding to both the object and the subject appear twice (See Figure 4: "The train goes *through/towards* the tunnel").

As in the case of prepositions, each stimulus representing prepositional locutions was contrasted with its opposite or with a different one ("The bicycle is *in front of/ behind* the house"/ "The bus is *in front of/next* to the store"). Similarly to what was described for the stimuli with prepositions, two related distractor elements were introduced in the scenes. In this condition the composition of the scene does not change, since the prepositional locutions that we study are all statics. Therefore, in every stimulus the subject is duplicated (See Figure 5. "The bus is *in front of/next* to the

store"). Each item had a specific configuration of the Regions of Interest (RoIs), depending on the positions of the objects. RoIs were always a square area covering the whole picture. Given our design, this variability in positions is not problematic, since the same picture served as visual stimuli for both contrasting preposition or prepositional locutions (for example, one version pictured "on" and the other "under"). Consequently, the target and competitor in a given display rotated across experimental lists.

[Insert Figure 3 here]

[Insert Figure 4 here]

It is worth mentioning that prepositions and prepositional locutions maintain a polysemic and heterogeneous character (Bosque, 2010). In this sense, many of the analyzed prepositions of this study had different semantic values. For example, the preposition *"de"* (EN: "from"/"to"/of) was used in its different meanings: SP: "Las flores *de* la niña"/EN: "The flower *of* the girl" (in a possessive sense, in English the phrase would be "The girl's flower") and SP: "La niña camina *de* la fuente a la otra fuente"/ EN "The girl walks *from* the fountain to the other fountain" (in a directional sense).

As mentioned above, two experimental lists were created (List A and List B). Each participant was exposed only to one condition of each scene ("The cat is *under* the table" or "The cat in *on* the table"). The visual stimuli were created by images of 800 x 600 pixels and presented as video format (800 x 600 pixels) on a monitor screen *17'' TFT of Tobii T120 Eye Tracker* set to 1024 x 768 pixels. Each stimulus has four graphic elements (target, competitor, and two distractors). A native Spanish speaker recorded the experimental sentences at a normal speaking velocity at 44,100 Hz. Recordings were edited using a sound editing software which allowed the clear-cut segmentation of the

words with a distance of a 1000 ms between each onset. See "Table summarizing the structure of the audio stimuli" in Appendix D. Collaborators and authors of this research evaluated and selected the different stimuli in search of the highest possible adequacy.

Procedure

Data was collected through the *Tobii Studio Software.* Each participant received the following instructions: "You will see some images and you will hear a sentence, search as quickly as possible for the correct image and continue looking at it". Before the beginning of the experiment, a calibration of 20s was performed, as well as four example trials. The stimuli were presented in a random order in List A or List B. A cross appeared at the center of the screen before the appearance of each stimulus, in order to guide the gaze of the participant. Each stimulus lasted around 6000 ms and the experiment was performed in six minutes.

Data Analysis

For the location of each object in the visual context, a corresponding area of interest for the location and size of the displayed pictures was defined using the software Tobii Studio. Critically, while the number of objects varied across items, all items presented a target and competitor object, which are the focus of this analysis. The Tobii system provides participants' gaze location at both the horizontal and vertical axes each 8,33ms (sample rate of 120 Hz). Consequently, it was possible to determine whether each gaze sample was located inside of any of the areas of interest. Critical time-windows started at 3000 milliseconds after the beginning of the sentence, marking the start of the first silent window following the critical preposition (3000 ms to 4000 ms from sentence onset), with the second marking the critical noun (4000 ms to 5000 ms from sentence onset) and the third, the second silent window, which appeared after the critical noun (5000 ms to 6000 ms from sentence onset). Using the R Project

software, steps of one ms were examined per participant. Trial and visual objects for each of these time windows and a value of 1 was given to the area of interest that participants were fixating on at time step. For visualization, fixations were aggregated into 50 ms steps (see Figure 5).

For statistical analysis, the log-transformed fixation proportion ratio between the target and the competitor (log ratio, see, Arai, Van Gompel, and Scheepers, 2007) was calculated per participant and per trial. To obtain the log ratio, the proportion of fixation towards the target plus a constant (i.e., 1) was divided by the proportion of fixation towards the competitor plus the same constant. Thus, in the log-transformed values, positive numbers represent the preference towards the target and negative numbers represent the preference towards the competitor. Inferential analysis was conducted with linear mixed-effects regressions (LMER, lmerTest in R). LMER analysis can model the variation of participants and items around the predictors, which is an important advantage in the context of psycholinguistics data, where there is variation among participants and items added to that of the experimental manipulation (see Clark, 1973). For this data, we began using maximal structure, and simplified it whenever the model did not converge. Doing so, recommendations of removing random correlation first given in Barr, Levy, Scheepers, and Tily (2013) were followed.

Results are divided in two groups. First, two main analyses concerning preposition comprehension are presented, and then, results on the comprehension of prepositional locutions. The first two main analyses of prepositions include a contrast between the experimental group against the Age-control group, the MLU-w-control group, and the Adult-control group, and a similar analysis by each time-window. In appendices A and B, we provide a secondary analysis in which we contrast the DLD

group against the Age- and the MLU-w-control group, and younger vs. older children. These appendices also present a similar analysis by time-window.

The first analysis used a successive difference contrast (MASS package in R) to compare the changes in time along the three time windows of interest. In both analyses, a treatment contrast (MASS package in R) was used to compare the between-subject predictors (i.e., independent groups). Thus, in both analyses, the intercept of the model represented the mean log-transformed fixation proportion ratio between target and competitor for the DLD group across the three time windows. The estimates, standard error of the mean, t-values, and p-values (lmerTest package in R) were reported.

The LMER structure of the first analysis included the fixed factors of participants' group as between-subject predictor, time window as within-subject predictor, and the interaction between them. It also included random intercepts for participants and items, a random slope of time window for subjects, and of group and time window for items. The second LMER structure included group as the single predictor, random intercepts for participants and items, and a random slope of group for items.

Results

Figure 5 shows the time course plots for the log-transformed fixation proportion difference between the target and the competitor objects, averaged by participants for each independent group and with error bands depicting the within-subjects adjusted 95% confidence intervals for the prepositions task.

[Insert Figure 5 here]

Two main effects can be observed: first, all participants are capable of distinguishing the target from the competitor beginning with the first time-window. This preference continues in the second and the third time-windows. The second effect is the evident advantage for the Adult-control group in terms of speed and effect size

compared to the children groups. Visual comparison among the children groups evidence a relative advantage for the Age-control group, in particular from the second time-window. The LMER clarify these differences. LMER results are presented in Table 3.

[Insert Table 3 here]

Results confirmed what was observed in the graphs, which essentially is the significant difference between the Adult-control group and the DLD experimental group. This is true, both in the global analysis (β = 0.315, *se* = 0.044, *t* = 7.124, $p<$ 0.001) and across the three critical time-windows (β = 0.315, *se* = 0.046, *t* = 6.885, $p<$ 0.001; β = 0.307, *se* = 0.055, *t* = 5.552, $p<$ 0.001; β = 0.364, *se* = 0.056, *t* = 6.441, $p<$ 0.001, respectively).

No other significant effects are observed. Only a marginal difference is found between DLD and Age-control, both globally, and in the first time-window as revealed by the window by window analysis (See Table 4). In general terms, the comprehension skills tested in real time eye tracking experiments suggests that the DLD group's performance is not significantly different from the Age-control groups. Finally, we eliminated the stimuli of some prepositions that graphically represent movement or directionality (e.g., “a”, “de”, “desde”, “hacia”, “hasta” in Spanish); (e.g., “to”, “from/of”, “since/from”, “towards”, “until” in English) because all groups of children (DLD, AGE, and MLU-w) registered very low levels of target recognition, which basically indicates a lack of comprehension and an arbitrary performance.

[Insert Table 4 here]

Data analysis, critical time-windows, and number of contrasts on prepositional locutions were identical to the prepositions analysis. We also present the same secondary analysis among the three children groups and the younger and older children in Appendices A and B.

Figure 6 shows the time course plots for the log-transformed proportion of fixation difference between the target and the competitor objects for the prepositional locutions task. Records present the time shifts of the dependent variable averaged by participants in each independent group. Error bands (grey area around the line) show the within-subjects adjusted 95% confidence intervals.

[Insert Figure 6 here]

Two observations from Figure 6 are evident. First, participants from all groups are capable of identifying the target from the first time-window, and this preference is maintained along the following critical time-windows. Second, the Adult-control group has a clear advantage both in terms of speed and the size of the preference effect, relative to the other groups. The results from the LMER analysis in Table 5 show two reliable effects. A significant overall difference between DLD group and the Adult-control group was found (β = 0.378, *se* = 0.047, *t* = 8.002, $p<0.001$). Additionally, a significant difference between the DLD group and the age-control group was also observed (β = 0.116, *se* = 0.045, *t* = 2.551, $p<0.05$).

[Insert Table 5 here]

The results from the second LMER analysis (Table 6) are coherent with those from the first analysis. We observed a significant effect between the experimental group (DLD) and the adult-control group, on each time-window (β = 0,370, *se* = 0,045, *t* = 8,274, *p*< 0,001; β = 0,389, *se* = 0,055, *t* = 7,119, *p*< 0,001; β = 0,374, *se* = 0,060, *t* = 6,233, *p*< 0,001, respectively). This analysis also clarifies that the advantage observed for the age-control group appears in the second time-window (β = 0,162, *se* = 0,051, *t* = 3,182, *p*< 0,01) and the third time-window (β = 0,374, *se* = 0,060, *t* = 6,233, *p*< 0,001) but not in the first one.

[Insert Table 6 here]

Discussion

The objective of the study was to record and analyze the capacity of bilingual children with DLD to comprehend, in real time, different prepositions and prepositional locutions within a simple sentence structure in Spanish. The research findings indicate, despite some differences, that both children with DLD and children in the control groups can comprehend prepositions and prepositional locutions in simple sentences in Spanish.

In the case of the prepositions, the analysis of the three windows (see Table 4) indicates that children with DLD present a comprehension that is not significantly different from that of the chronological control group, which spreads homogeneously from the beginning to the end of the stimuli. Both young children (DLD1, AGE1, and MLU-w1) and older children (DLD2, AGE2, and MLU-w2) similarly comprehend the different prepositions (see Appendix A, Figure 7, Tables 7 and 8). The global analysis also confirms these outcomes (Table 3). This finding would be in line with studies that point to a consolidation in the ability of children with DLD to understand this class of function words (Puglisi, Befi-Lopes and Takiuchi, 2005; Watkins and Rice 1991).

In the case of prepositional locutions, the analysis of the three time-windows (Table 6) shows a significant difference between the DLD group and the Age control group. In more detail, in the first window of analysis, which represents 1000 ms of silence immediately after the linguistic key (prepositional locution), the three groups of children (DLD, AGE, MLU-w) present a similar level of comprehension. However, in the second and third window of analysis, a significant difference is observed between the DLD group and the Age control group. The DLD group also presents a similar performance to the MLU-w control group. Again, the global analysis (see Table 5) confirms this result. Statistically, the effect found between the DLD group and the Age control group regarding prepositional locutions appears to be mainly due to the difference between the older children (DLD2 and AGE2), as can be observed in the Appendix B (Figure 8 and Table 9). Thus, the pattern of comprehension is more heterogeneous and statistically different. Consequently, it can be argued that the DLD group responds relatively well, and that the Age group responds significantly better. This suggests that children with DLD do not exactly evolve in the same way as children with typical language development in their comprehension of prepositional locutions and that their performance would tend to be slightly different in this respect. Further, we can see that younger TD children and children with DLD, in the first time-window of analysis (3000-3999 ms), present a relatively high fixation proportion towards the target, but nevertheless, in the following time-windows (4000-5999 ms) they do not maintain the visual gaze proportion at the same rate as older TD children do. As such, the advantage of older children without DLD could have to do, on the one hand, with a greater ability to process sentences more quickly and effectively and, on the other, a better-established knowledge of these linguistic structures.

The compound structure of prepositional locutions in Spanish (SP: “al lado de”, “alrededor de”, “cerca de”, “debajo de”, “delante de”, “dentro de”, “detrás de”, “encima de”, “en frente de”, “fuera de”, “junto a”, “lejos de”); (EN: “beside/next to”, “around”, “close to”, “under/below of”, “in front of/opposite of”, “inside of”, “behind of”, “above of”, “in front of”, “outside of”, “next to”, “far from”) could also have an effect on the difference observed between both groups of children (DLD and AGE). Linguistically, it is known that prepositions assume a syntactic function in the connection of different phrasal elements (Grela, Rashiti and Soares, 2004). This assumption also applies to prepositional locutions, in which case the connection of more than one morphological morpheme within the context of different phrasal elements could produce more difficulties in children with DLD. However, an explanation related to greater cognitive effort made by children with DLD when comprehending language is put forward by Evans, Saffran and Robe-Torres (2009). This could likewise account for the observed difference with prepositions and prepositional locutions. According to this view, this performance does not relate to a lack in perception, but to a greater cognitive effort made by children with DLD due to their fragile and ineffective use of an implicit learning mechanism. This suggests that the issue of comprehending the relatively more complex structure of prepositional locutions may add both a linguistic and a cognitive load to this type of tasks for children with DLD.

Finally, we argue that the prepositional locution task (Figure 6) presents a lower difficulty in comparison with the preposition task (Figure 5), since the fixation proportions of all four groups is higher with prepositional locutions and lower with prepositions. In other words, in the relatively more difficult task (prepositions) there are less significant differences between the DLD group and the age group, since the complexity of the task is reflected in a more homogeneous comprehension pattern

between the two groups. On the other hand, when the complexity of the task is reduced (prepositional locutions), the pattern of comprehension is more heterogeneous and more statistically significant. Possibly, the observed effect is related with the higher phonological salience of prepositional locutions in the Spanish language, since the advantage in terms of comprehension concerns all children, with and without DLD, as well as adults.

In sum, the main research findings in this study indicate, despite some differences regarding the comprehension of prepositional locutions, that both children with DLD and children in the control groups can, in general, comprehend prepositions and prepositional locutions in simple sentences in Spanish. As mentioned before, several authors have suggested that children with DLD tend to perform better in comprehension tasks than in production tasks (Andreu, Sanz-Torrent and Rodriguez-Ferreiro, 2016; Castro-Rebolledo, Giraldo-Prieto, Hincapie-Haenao, Lopera and Pineda, 2004; Dale, Price, Bishop and Plomin, 2003; Leonard, 2014; Puglisi, Befi-Lopes and Takiuchi, 2005). Specifically referring to Spanish-speaking children with DLD, Leonard (2014) supports the idea that they have better skills in language comprehension than in language production. Other studies using the eye-tracking method to investigate language comprehension in Spanish have introduced empirical evidence, pointing to a less impaired linguistic comprehension in children with DLD (Andreu, Sanz-Torrent, Guardia and MacWhinney, 2011; Andreu, Sanz-Torrent and Rodriguez-Ferreiro, 2016; Andreu, Sanz-Torrent and Trueswell, 2013). Our study also supports this last idea empirically. However, it is relevant to highlight that our findings refer to the comprehension of Spanish grammatical morphemes within simple structures, using an online technology, and that assessment of more complex structures using the same technology is still required. Research on the offline comprehension of more complex

structures by children with DLD in Spanish has shown significant differences between these children and a control group (Coloma, Maggiolo and Pavez, 2013; Coloma, Mendoza and Carballo, 2017; Coloma and Pavez, 2017). Future studies would have to evaluate the comprehension of children with DLD in circumstances that integrate elements of these two lines of research: the online methodology that adequately captures the cognitive processes of DLD linguistic comprehension, and the evaluation of more complex sentence structures closer to the linguistic reality surrounding children with DLD.

A clinical intervention could begin with the implementation of simple sentences containing prepositions and prepositional locutions, since they have been shown to be understood by children with DLD, and advance to the consolidation of the comprehension of the specific markers which we have found still cause some specific difficulties in children with DLD in a more detailed account. Since the difficulty with prepositions and prepositional locutions seems to point to a limitation related to performance rather than to competence, intervention should focus on these morphological markers in a speech therapy context. Once the performance limitations in simple sentences are overcome, addition of new elements in the simple structure of the sentence may be added in order to make them more complex in linguistic and cognitive terms, but in a controlled manner, since such complex comprehension tasks involve skills beyond linguistic knowledge and competence (Frizelle, O'Neil and Bishop, 2017) that can presumably lead to a cognitive overload. Such an intervention could approach real world discursive contexts in which prepositions and prepositional locutions can be more successfully comprehended and performance could improve. Working with the comprehension of simple sentences and the gradual addition of more difficult grammatical morphemes could help to enhance the comprehension of a growing

complex grammar. Since the problem regarding prepositions and prepositional locutions seems more related to production than to comprehension, this last ability (comprehension) should function as an aid in the production of prepositions and prepositional locutions. For example, morphological awareness could be used for the identification of correct or incorrect prepositions in sentences, since comprehension of these morphological function words is preserved. In future studies, a language exposure questionnaire could be applied to determine and/or confirm bilingualism in order to refine the discussion of this kind of research. Additionally, future studies should investigate simultaneously language production and language comprehension under similar experimental conditions, in order to better understand the nature of these abilities in children with DLD.

Finally, despite the fact that the eye-tracking tool is far from being sufficiently portable or economically and methodologically accessible in the clinical field, the empirical research outcomes of the type of study we have conducted here might ensure useable information for language therapists to design a more adjusted psycholinguistic intervention in children with DLD. We argue that the task in this experiment is clinically useful in order to assess the basic language comprehension of children with DLD, and that the empirical differences seem to be more linked to performance factors. Relatedly, it is important to acknowledge that, since the task requires only comprehension of a single grammatical morpheme (a preposition or a prepositional locution), differences in real world tasks may also be linked to performance issues.

Future studies with the use of different and more user-friendly technologies could perhaps better elucidate the difference in competence and performance for children with DLD. Under our perspective, in terms of intervention, the functional comprehension of these children in day-to-day natural linguistic contexts requires both

the identification of the typical mistakes they make in order to strengthen language knowledge, and the use of sentences with lower processing load. The synthesis of new and/or more complex language constructions and low processing load contexts, in the presence of visual scenes, might encourage the appropriate use of the grammatical morphemes under consideration, and raise the possibility of a better prognosis.

APPENDIX A (Prepositions)

In this appendix, we present two further analyses, which involved a comparison between the experimental group and the two child groups, and the age predictor. The first analysis includes a direct comparison among time-windows, and the second one contrasts these groups and the age predictor in each time-window separately. Data analysis is identical to that in the previous contrasts (see Tables 7 and 8).

[Insert Figure 7 here]

The results from the LMER analysis reflect these differences. Tables 7 and 8 show a reliable effect of the age predictor (younger vs. older children). Interestingly, while the global analysis (Table 7) shows an overall effect of children's age (β = 0.080, *se* = 0.027, *t* = 2.992, $p<0.01$), the window-by-window analysis reveals that this effect does, in fact, appear only in the second window (β = 0.098, *se* = 0.034, *t* = 2.91, $p<0.01$). Finally, the analysis presented in Table 8 shows a significant difference between the DLD group and the age-control group only in first time-window (β = 0.071, *se* = 0.035, *t* = 2.019, $p<0.05$).

[Insert Table 7 here]

[Insert Table 8 here]

APPENDIX B (Prepositional locutions)

Appendix B presents two further analyses. The first one contrasts the experimental group against the two child groups, with an age predictor and across time-windows as a factor. The second one does the same, but window by window. All aspects of data analysis are identical to those in the previous contrasts (see Tables 9 and 10). The results presented in Figure 8 show that older children from all groups demonstrate a large preference for the target compared to the competitor. However, among younger children there seem to be some differences between the three groups of interest. Younger children with DLD seem to face some difficulty in distinguishing between the target and the competitor. The younger children in the age-control group seem more able to do so. The younger children from the MLU-w-control group, for their part, also prefer the target relative to the competitor, however, in a less clear and stable way relative to the younger age-control group children or older children in general.

[Insert Figure 8 here]

These contrasts are coherent with the previous analysis. Overall, the graphs show a clear advantage for older children relative to younger children in all three groups. Interestingly, all three younger children groups exhibit an initial trend towards the target in the first critical time-window. However, this trend vanishes in the second and third time-window. Older children, by contrast, began to prefer the target over the competitor in the first time-window and maintained such preference in the second and third time-windows. This pattern is confirmed by the significant effect of the age predictor in the global analysis (β = 0,107, *se* = 0,029, t = 3,63, p< 0,001), and in the window-by-window analysis.

[Insert Table 9 here]

[Insert Table 10 here]

APPENDIX C (List of prepositions and prepositional locutions)

[Insert Table 11 here]

APPENDIX D (Structure of the audio stimuli)

[Insert Table 12 here]

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Tables and Figures in order of appearance

Table 1. Descriptive statistics of individual measures per group and age

	DLD		**AGE**		**MLU-w**	
Full sample (n=24)	*Means (SD)*	*Range*	*Means (SD)*	*range*	*Means (SD)*	*range*
Age (years)	7.8 (2.2)	4.5 – 12.6	7.8 (2)	4.5 – 12.2	6.8 (1.6)	4.5 – 9.4
MLU-w	4.9 (1.9)	1.1 – 7.9	8.9 (2.4)	5.2 – 14.6	5.4 (1.3)	3.4 – 7.8
PPVT-III	86.5 (16.4)	55.0 – 114.0	106.4 (6.6)	93.0 – 117.0	108.1 (8.8)	87.0 – 121.0
CEG	16.8 (17)	1.0 – 55.0	40.0 (24.8)	10 – 95.0	34.54 (24.9)	4.0 – 75.0
KBIT-VOC	88.6 (15.7)	59.0 – 127.0	101.3 (24.4)	9.0 – 137.0	100.1 (14.8)	64.0 – 120.0
KBIT-MAT	95.6 (15.8)	70 – 127.0	97.17 (15.40)	61.0 – 119.0	104.6 (14.4)	55.0 – 123.0
Younger children (n=12)	*Means (SD)*	*Range*	*Means (SD)*	*range*	*Means (SD)*	*range*
Age (years)	6 (1)	4.5 – 8.2	6.3 (1.2)	4.5 – 8.2	5.4 (0.7)	4.5 – 6.4
MLU-w	3.8 (2)	1.1 – 7.9	7.8 (2)	5.2 – 11.6	4.5 (0.8)	3.4 – 6.0
PPVT-III	89.8 (17.2)	55.0 – 114.0	109.5 (5.8)	102.0 – 117.0	109.1 (8.9)	93.0 – 121.0
CEG	16.0 (17.6)	1.0 – 55.0	34.2 (16.8)	15.0 – 60.0	37.0 (23.1)	5.0 – 70.0
KBIT-VOC	90.5 (17.5)	59.0 – 127.0	92.8 (30.9)	9.0 – 124.0	97.4 (17.8)	64.0 – 120.0
KBIT-MAT	98.3 (17.9)	70.0 – 127.0	99.8 (18.6)	61.0 – 119.0	104.1 (10.8)	82.0 – 119.0
Older children						

(n=12)	*Means (SD)*	*Range*	*Means (SD)*	*range*	*Means (SD)*	*range*
Age (years)	9.7 (1.3)	8.3 – 12.6	9.4 (1.3)	8.3 – 12.1	8.2 (1)	6.6 – 9.4
MLU-w	5.9 (1.2)	4.2 – 7.7	10. 2 (2.2)	7.3 – 14.6	6.2 (1)	5.0 - 7.9
PPVT-III	83.3 (15.7)	55.0 – 110.0	103.3 (6)	93.0 – 112.0	107.1 (8.9)	87.0 – 121.0
CEG	17.7 (17)	1.0 – 50.0	45.8 (30.5)	10.0 – 95.0	32.0 (27.4)	4.0 – 75.0
KBIT-VOC	86.8 (14.3)	59.0 – 111.0	109.8 (11.6)	88.0 – 137.0	102.9 (11.3)	73.0 – 114.0
KBIT-MAT	93.0 (13.8)	76.0 – 112.0	98.5 (12.2)	68.0 – 118.0	105.1 (17.8)	55.0 – 123.0

Table 2. Pairwise contrasts between the reference group and the control groups (Welch two sample *t*-test, two-tailed)

	DLD vs. AGE		**DLD vs. MLU-w**	
Full sample (n=24)	*T*	*p*	*t*	*P*
Age (years)	-0.04	0.964	1.91	0.063
MLU-w	6.46	0.000	-1.07	0.292
PPVT-III	5.52	0.000	-5.68	0.000
CEG	3.77	0.001	-2.88	0.006
KBIT-VOC	2.14	0.039	-2.62	0.012
KBIT-MAT	0.78	0.442	-2.04	0.047
Younger children (n=12)	*T*	*p*	*t*	*P*
Age (years)	0.44	0.665	1.51	0.149
MLU-w	4.67	0.000	-0.80	0.435
PPVT-III	3.66	0.003	-3.20	0.005
CEG	2.56	0.018	-2.13	0.045
KBIT-VOC	0.41	0.688	-0.81	0.429
KBIT-MAT	0.27	0.791	-0.95	0.352
Older children (n=12)	*T*	*p*	*t*	*P*
Age (years)	-0.55	0.588	3.26	0.004
MLU-w	6.55	0.000	-1.01	0.323
PPVT-III	4.21	0.001	-4.84	0.000
CEG	2.83	0.012	-1.90	0.074
KBIT-VOC	4.45	0.000	-3.21	0.004
KBIT-MAT	0.94	0.356	-1.86	0.078

Figure 1. Preposition stimulus

EN: “The cat is on the table” (Target: cat on the table, Competitor: cat under the table).

SP: “El gato está *sobre* la mesa”.


12
3
6
9

Figure 2. Prepositional locution stimulus

EN: "The bicycle is *in front of* the house" (Target: bicycle in front of the house, Competitor: bicycle behind the house).

SP: “La bicicleta está *enfrente de* la casa”.

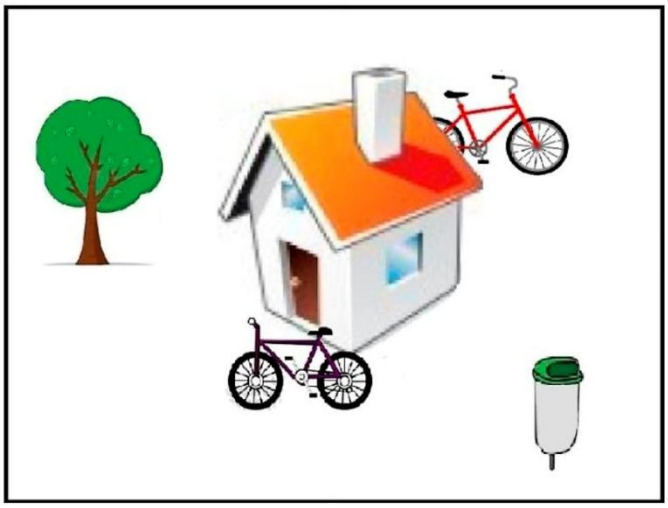


Figure 3. Stimulus of Preposition of movement or direction

EN: “The bee flies *towards* the flower, *from* the flower” (Target: second flower, Competitor: first flower).

SP: “La abeja vuela *hasta* la flor, *desde* la flor”.

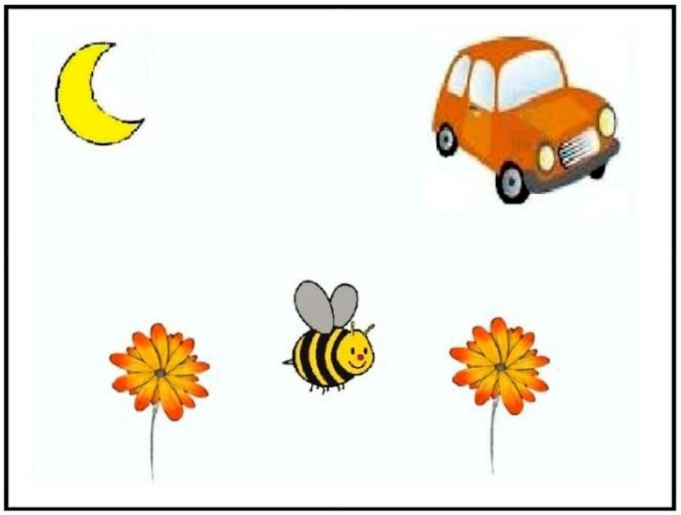
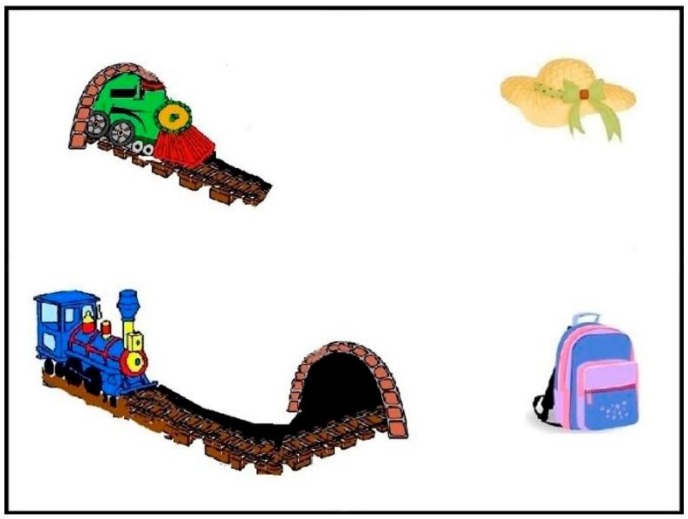


Figure 4. Stimulus of Preposition of movement or direction

EN: "The train goes *towards* the tunnel" (Target: train towards the tunnel, Competitor: train through the tunnel).

SP: "El tren va *hacia* el túnel".



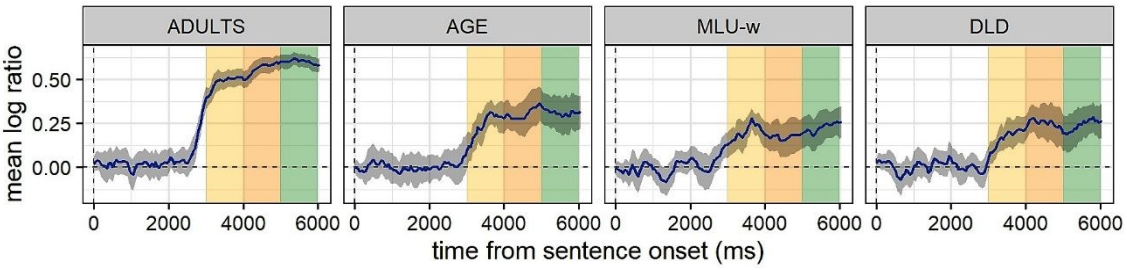


Figure 5. Mean fixation proportion log-ratio between target and competitors by group and time-window in the prepositions task. Grey areas represent the within-subject adjusted 95% confidence intervals.

Table 3. Main and interaction effects in the linear mixed-effects regression on fixation proportion log-ratio between target and competitor in the prepositions task.

	Estimate	***Se***	***T***	***P***	
(Intercept)	0.158	0.036	4.423	0.000	***
Age-control	0.071	0.036	1.987	0.050	.
MLU-control	0.035	0.036	0.978	0.331	
Adult-control	0.315	0.044	7.124	0.000	***
Time-window2-1	0.089	0.035	2.508	0.014	*

Time-window3-2	0.075	0.037	2.003	0.048	*
Age-control:Time-window2-1	-0.024	0.050	-0.488	0.626	
MLU-control:Time-window2-1	-0.109	0.050	-2.184	0.031	*
Adult-control:Time-window2-1	-0.008	0.050	-0.157	0.876	
Age-control:Time-window3-2	0.001	0.053	0.015	0.988	
MLU-control:Time-window3-2	-0.052	0.053	-0.986	0.327	
Adult-control:Time-window3-2	0.049	0.053	0.926	0.357	

Table 4. Main and interaction effects in the linear mixed-effects regression on fixation proportion log-ratio between target and competitor by time-window in the prepositions task.

Time-window 1	***Estimate***	***Se***	***T***	***p***	
(Intercept)	0.158	0.035	4.477	0.001	***
Age-control	0.071	0.037	1.947	0.060	.
MLU-control	0.035	0.036	0.980	0.332	
Adult-control	0.315	0.046	6.885	0.000	***

Time-window 2	***Estimate***	***Se***	***T***	***p***	
(Intercept)	0.246	0.044	5.652	0.000	***
Age-control	0.047	0.049	0.956	0.343	
MLU-control	-0.073	0.053	-1.374	0.178	
Adult-control	0.307	0.055	5.552	0.000	***

Time-window 3	***Estimate***	***Se***	***t***	***p***	
(Intercept)	0.232	0.044	5.249	0.000	***
Age-control	0.072	0.055	1.312	0.195	
MLU-control	-0.017	0.054	-0.305	0.761	
Adult-control	0.364	0.056	6.441	0.000	***

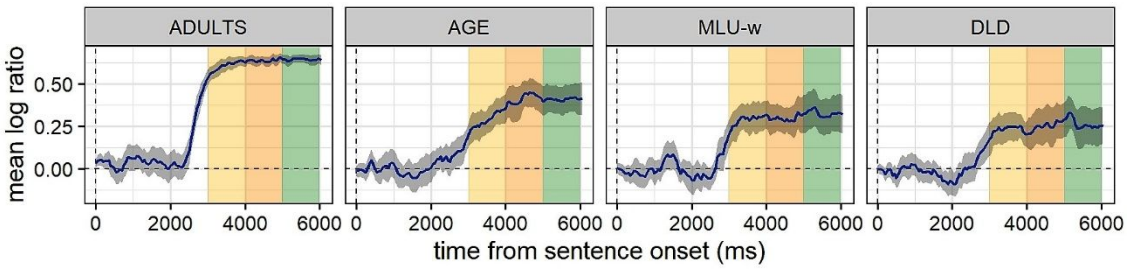


Figure 6. Mean fixation proportion log-ratio between target and competitors by group and time-window for the prepositional locutions task. Grey areas represent the within-subject adjusted 95% confidence intervals.

Table 5. Main and interaction effects in the linear mixed-effects regression on fixation proportion log-ratio between target and competitor in the prepositional locutions task.

	Estimate	*Se*	*t*	*P*	
(Intercept)	0.244	0.038	6.442	0.000	***
Age-control	0.116	0.045	2.551	0.013	*
MLU-control	0.053	0.048	1.121	0.267	
Adult-control	0.378	0.047	8.002	0.000	***
Time-window2-1	0.015	0.028	0.540	0.590	
Time-window3-2	0.020	0.028	0.709	0.480	
Age-control:Time-window2-1	0.111	0.039	2.817	0.005	**
MLU-control:Time-window2-1	0.001	0.039	0.029	0.977	
Adult-control:Time-window2-1	0.018	0.039	0.468	0.640	
Age-control:Time-window3-2	-0.026	0.037	-0.711	0.478	
MLU-control:Time-window3-2	0.007	0.037	0.187	0.852	
Adult-control:Time-window3-2	-0.015	0.037	-0.406	0.685	

Table 6. Main and interaction effects in the linear mixed-effects regression on fixation proportion log-ratio between target and competitor by time-window in the prepositional locutions task.

Time-window 1	*Estimate*	*Se*	*t*	*p*	
(Intercept)	0.227	0.038	5.981	0.000	***
Age-control	0.051	0.043	1.183	0.246	
MLU-control	0.050	0.042	1.188	0.243	
Adult-control	0.370	0.045	8.274	0.000	***

Time-window 2	*Estimate*	*Se*	*t*	*p*	
(Intercept)	0.242	0.044	5.461	0.000	***
Age-control	0.162	0.051	3.182	0.002	**
MLU-control	0.052	0.054	0.958	0.343	
Adult-control	0.389	0.055	7.119	0.000	***

Time-window 3	*Estimate*	*Se*	*t*	*P*	
(Intercept)	0.262	0.045	5.865	0.000	***
Age-control	0.136	0.058	2.327	0.023	*
MLU-control	0.058	0.059	0.991	0.325	
Adult-control	0.374	0.060	6.233	0.000	***

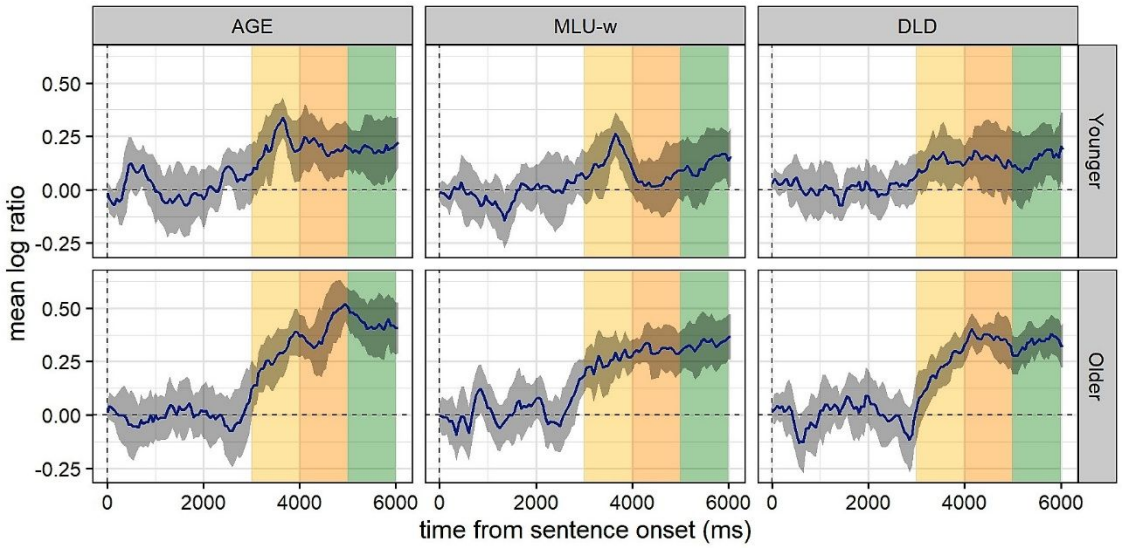


Figure 7. Mean fixation proportion log-ratio between target and competitors by group, time-window and age for the prepositions task. Grey areas represent the within-subject adjusted 95% confidence intervals.

Table 7. Main and interaction effects in the linear mixed-effects regression on fixation proportion log-ratio between target and competitor in the prepositions task.

	Estimate	*se*	*t*	*p*	
(Intercept)	0.212	0.035	6.115	0.000	***
Age-control	0.063	0.034	1.848	0.070	.
MLU-control	-0.018	0.034	-0.529	0.599	
Time-window2-1	0.089	0.038	2.358	0.021	*
Time-window3-2	-0.014	0.033	-0.428	0.669	
Age	0.080	0.027	2.992	0.004	**
Age-control:Time-window2-1	-0.024	0.052	-0.468	0.641	
MLU-control:Time-window2-1	-0.109	0.052	-2.093	0.039	*
Age-control:Time-window3-2	0.025	0.046	0.548	0.584	
MLU-control:Time-window3-2	0.057	0.046	1.242	0.215	
Time-window2-1:Age	0.071	0.037	1.933	0.056	.
Time-window3-2:Age	-0.012	0.032	-0.373	0.709	
Age-control:Age	0.004	0.033	0.122	0.903	
MLU-control:Age	0.015	0.033	0.438	0.663	
Age-control:Time-window2-1:Age	-0.005	0.052	-0.091	0.927	
MLU-control:Time-window2-1:Age	0.005	0.052	0.095	0.924	
Age-control:Time-window3-2:Age	0.037	0.046	0.817	0.414	
MLU-control:Time-window3-2:Age	-0.009	0.046	-0.188	0.851	

Table 8. Main and interaction effects in the linear mixed-effects regression on fixation proportion log-ratio between target and competitor by time-window in the prepositions task.

Time-window 1	*Estimate*	*se*	*t*	*p*	
(Intercept)	0.158	0.035	4.511	0.001	***
Age-control	0.071	0.035	2.019	0.048	*
MLU-control	0.035	0.036	0.977	0.334	
Age	0.036	0.037	0.979	0.349	
Age-control:Age	-0.005	0.040	-0.130	0.898	
MLU-control:Age	0.014	0.041	0.343	0.736	

Time-window 2	*Estimate*	*se*	*t*	*p*	
(Intercept)	0.246	0.041	6.018	0.000	***
Age-control	0.047	0.044	1.080	0.287	
MLU-control	-0.073	0.048	-1.542	0.137	
Age	0.108	0.037	2.939	0.009	**
Age-control:Age	-0.010	0.044	-0.226	0.822	
MLU-control:Age	0.019	0.053	0.364	0.721	

Time-window 3	*Estimate*	*se*	*t*	*p*	
(Intercept)	0.232	0.043	5.462	0.000	***
Age-control	0.072	0.053	1.371	0.177	
MLU-control	-0.017	0.050	-0.328	0.744	
Age	0.095	0.046	2.085	0.051	.
Age-control:Age	0.027	0.056	0.489	0.629	
MLU-control:Age	0.011	0.061	0.173	0.864	

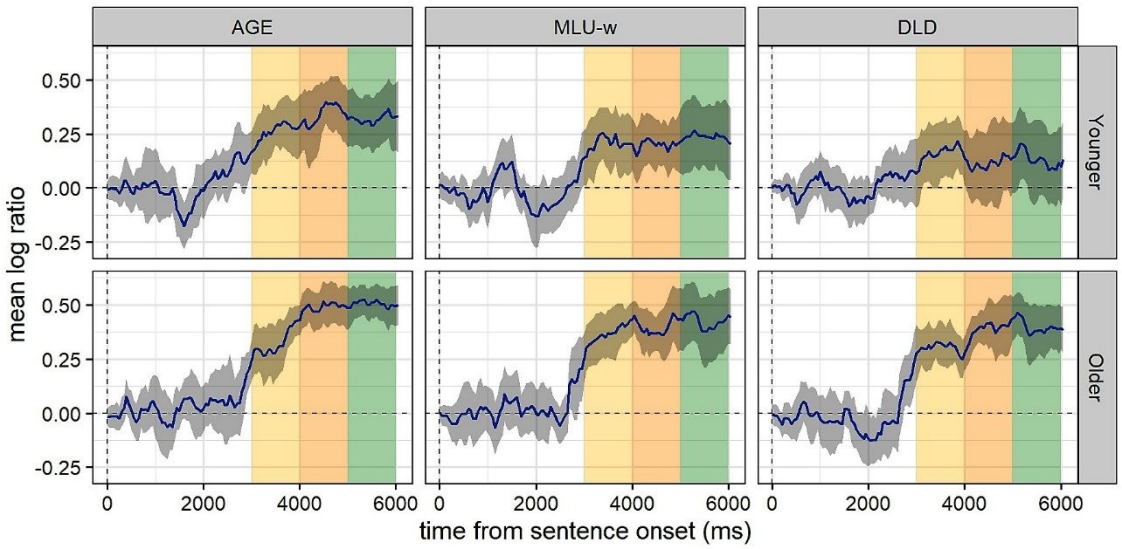


Figure 8. Mean fixation proportion log-ratio between target and competitors by group, time-window and age for the prepositional locutions task. Grey areas represent the within-subject adjusted 95% confidence intervals.

Table 9. Main and interaction effects in the linear mixed-effects regression on fixation proportion log-ratio between target and competitor in the prepositional locutions task.

	Estimate	*se*	*T*	*p*	
(Intercept)	0.244	0.037	6.623	0.000	***
Age-control	0.116	0.043	2.667	0.010	**
MLU-control	0.053	0.046	1.171	0.247	
Time-window2-1	0.015	0.030	0.496	0.621	
Time-window3-2	0.020	0.030	0.673	0.503	
Age	0.107	0.029	3.635	0.001	***
Age-control:Time-window2-1	0.111	0.043	2.588	0.011	*
MLU-control:Time-window2-1	0.001	0.043	0.027	0.979	
Age-control:Time-window3-2	-0.026	0.042	-0.624	0.534	
MLU-control:Time-window3-2	0.007	0.042	0.164	0.870	
Time-window2-1:Age	0.058	0.030	1.919	0.057	.
Time-window3-2:Age	0.000	0.030	-0.010	0.992	
Age-control:Age	-0.043	0.041	-1.057	0.294	
MLU-control:Age	-0.016	0.041	-0.383	0.703	
Age-control:Time-window2-1:Age	-0.015	0.043	-0.340	0.734	
MLU-control:Time-window2-1:Age	-0.034	0.043	-0.802	0.424	
Age-control:Time-window3-2:Age	0.018	0.042	0.428	0.670	
MLU-control:Time-window3-2:Age	-0.004	0.042	-0.094	0.925	

Table 10. Main and interaction effects in the linear mixed-effects regression on fixation proportion log-ratio between target and competitor by time-window in the prepositional locutions task.

Time-window 1	*Estimate*	*se*	*t*	*p*	
(Intercept)	0.227	0.037	6.070	0.000	***
Age-control	0.051	0.042	1.203	0.240	
MLU-control	0.050	0.042	1.201	0.239	
Age	0.069	0.031	2.191	0.040	*
Age-control:Age	-0.040	0.042	-0.954	0.350	
MLU-control:Age	0.008	0.041	0.205	0.839	

Time-window 2	*Estimate*	*se*	*t*	*p*	
(Intercept)	0.242	0.043	5.636	0.000	***
Age-control	0.162	0.049	3.273	0.002	**
MLU-control	0.052	0.051	1.006	0.321	
Age	0.127	0.034	3.677	0.001	***
Age-control:Age	-0.054	0.049	-1.112	0.272	
MLU-control:Age	-0.026	0.049	-0.532	0.598	

Time-window 3	*Estimate*	*se*	*t*	*p*

(Intercept)	0.262	0.044	5.923	0.000	***
Age-control	0.136	0.058	2.353	0.023	*
MLU-control	0.058	0.059	0.993	0.326	
Age	0.126	0.040	3.131	0.003	**
Age-control:Age	-0.036	0.057	-0.644	0.523	
MLU-control:Age	-0.030	0.057	-0.527	0.601	

Table 11. Prepositions and prepositional locutions used in List A.

Preposition/ Prepositional locution	**Item**	**Target**	**Competitor**
1. *bajo*	*El gato está bajo la mesa* (The cat is under the table).	cat under the table	cat on the table
2. a	*El niño va a la cama desde la otra cama* (The boy goes to the bed from the other bed).	bed in front of the boy	bed behind the boy
3. *de*	*La niña camina de la casa* a la casa (The girl walks from the house to the house).	house behind the girl	house in front of the girl
4. *de*	*El perro pasea del árbol al árbol* (The dog goes from the tree to the tree).	tree behind the dog	tree in front of the dog
5. *hasta*	*La niña camina hasta la fuente desde la fuente* (The girl walks to the fountain from the fountain).	fountain in front of the girl	fountain behind the girl
6. *desde*	*La abeja vuela desde la flor a la flor* (The bee flies to the flower from the flower).	flower behind the bee	flower in front of the bee
7. *hacía*	*La niña salta hacía la cama* (The girl jumps towards the bed).	bed in front of the girl	bed behind the girl
8. *entre*	*El señor camina entre los árboles* (The gentleman walks between the trees).	man between the trees	man in front of the trees
9. *para*	*La flor es para la niña* (The flower is for the girl).	girl without a flower	girl with a flower
10. *por*	*La niña va por el parque* (The girl goes through the park).	girl in the park	girl towards the park

11. *hacía*	*El tren va hacía el túnel* (The train goes towards the tunnel)	train towards the tunnel	train through the tunnel
12. *con*	*El perro está con la oveja* (The dog is with the sheep).	the sheep on the side of the dog	the sheep opposite the dog
13. *en*	*El chico está en el autobús* (The boy is on the bus).	boy in the bus	boy outside the bus
14. *sin*	*La señora va sin sombrero* (The lady goes without a hat).	lady without a hat	lady with a hat
15. *tras*	*El chico grita tras el árbol* (The boy shouts behind the tree)	boy behind the tree	boy in front of the tree
16. *por*	*La chica va por la montaña* (The girl goes through the mountain).	girl through the mountain	girl towards the mountain
17. *ante*	*El coche está ante la casa* (The car is in front of the house).	car in front of the house	car behind the house
18. *sobre*	*El libro está sobre la cama* (The book is on the bed).	book on the bed	book under the bed
19. *entre*	*Los árboles están entre los columpios* (The trees are between the swings).	trees between the swings	trees around the swings
20. *junto a*	*El niño canta junto a la escuela* (The boy sings next to the school).	boy next to the school	boy inside the school
21. *enfrente de*	*La bicicleta está en frente de la casa* (The bicycle is in front of the house).	bicycle in front of the house	bicycle behind the house
22. *encima de*	*El regalo está encima de la mesa* (The present is on the table).	present on the table	present under the table
23. *delante de*	*La niña corre delante de la granja* (The girl runs in front of the farm).	girl in front of the farm	girl behind the farm
24. *detrás de*	*La pelota está detrás del árbol* (The ball is behind the tree).	ball behind the tree	ball in front of the tree
25. *debajo de*	*El gato está debajo de la ventana* (The cat is under the window)	cat under the window	cat on top of the window

26. *al lado de*	*El autobús para al lado de la tienda* (The bus stops next to the store).	bus next to the store	bus in front of the store
27. *dentro de*	*El ratón está dentro de la taza* (The mouse is inside the cup).	mouse inside the cup	mouse outside of the cup
28. *fuera de*	*El peluche está fuera de la caja* (The teddy bear is outside of the box).	teddy bear outside of the box	teddy bear inside the box
29. *cerca de*	*El avión está cerca de la nube* (The plane is near the cloud)	plane near the cloud	plane away from the cloud
30. *lejos de*	*La niña está lejos de la nevera* (The girl is far from the fridge).	girl far from the fridge	girl near the fridge

i. The above sentences were the items in LIST A. LIST B was composed of the opposite targets and competitors in comparison to LIST A. For example, LIST B/item 12: *El perro está contra la oveja* (The dog stands opposite/across from the sheep).

ii. The prepositions represented in items 2-11 were eliminated due to their low validity.

iii. In some cases (i.e., items 19 and 20) the stimuli contrast a preposition with a prepositional locution: *El niño canta junto a la escuela* (The boy sings next to the school) vs. *El niño canta en la escuela* (The boy sings inside the school).

Table 12. Table summarizing the structure of the audio stimuli.

Subject	**Verb**	**Preposition/ Prepositional locution**	**(Silence)**	**Complements**	**Final silence**
0-999ms	1000-1999ms	2000-2999ms	3000-3999ms	4000-4999ms	5000-5999ms