Eye movements of deaf students in expository versus narrative texts

Article

Accepted Version

Gómez-Merino, N., Fajardo Bravo, I., Ferrer Manchón, A. M. and Joseph, H. ORCID: https://orcid.org/0000-0003-4325-4628 (2022) Eye movements of deaf students in expository versus narrative texts. American Annals of the Deaf, 167 (3). pp. 313-333. ISSN 1543-0375 doi: https://doi.org/10.1353/aad.2022.0030 Available at https://centaur.reading.ac.uk/104163/

Eye Movements of Deaf Students in Expository versus Narrative Texts

Nadina Gómez-Merino*[1], Inmaculada Fajardo Bravo[1], Antonio M. Ferrer Manchón[1] and Holly Joseph[2]

*Corresponding author

1 University of Valencia (Spain)

2 University of Reading (Reading, United Kingdom)

Eye Movements of Deaf Students in Expository versus Narrative Texts

Abstract

Text comprehension, a daily academic activity at primary and secondary school, is especially challenging for deaf or hard of hearing (DHH) students. The present study was aimed at analysing the effect of text genre (narrative vs. expository) on accuracy and eye movement patterns during the text comprehension of DHH students (age range: 9-15 years) users of oral language as preferred communication mode in relation to a typically hearing (TH) chronological age-matched control group. Results showed that comprehension accuracy was similar across text genres for both groups and that TH participants outperformed DHH participants. Regarding eye movements, both groups spent longer time and made more regressive fixations in the expository than in the narrative text but DHH participants showed longer saccade amplitude in the expository than the narrative text which could be interpreted as evidence of better self-regulation of DHH readers in the easiest and more familiar narrative text structure.

Keywords: Deafness, reading, eye movements, text genre, text comprehension

Students who are deaf or hard of hearing (DHH) have traditionally been found to show difficulties in achieving an age-appropriate reading comprehension (e.g. Barajas et al., 2016; Traxler, 2000). Knowledge and monitoring of text genre are important factors in text comprehension (Clinton et al., 2020; Duke, 2011; Mar et al., 2021) research in this area with students who are DHH is scarce and difficult to compare due to methodological differences. For example, Figueroa et al. (2020) found that as a group typically hearing (TH) students outperformed DHH students in reading comprehension accuracy regardless the text genre, while in a case study, Banner and Wang (2011) found that DHH participants reported using more monitoring strategies when reading narrative than expository texts. However, the latter study did not measure reading comprehension accuracy or include a control group. As these two examples illustrate, previous studies differ enormously in methodology and, in particular, in how reading comprehension is measured (e.g., the product versus the process of comprehension) which suggests that a comprehensive study on the effect of text genre on comprehension should include both type of measures. Therefore, in order to address this issue and gain a better understanding of reading comprehension in students with DHH, the present study focused on comparing both accuracy of responses to reading comprehension questions (the product) and eye-movement patterns during text processing (the process) of students with DHH and TH modulated by text genre: expository and narrative texts. To our knowledge, no studies have explored the effect of text genre on reading comprehension in children with DHH in comparison to children with TH using measures of reading comprehension and process (in this case eye-movements), and this is one of the main goals and added value of the present research.

Reading comprehension as a function of text genre in participants with typical hearing

When we talk about narrative texts, we refer to pieces of writing such as stories or novels in which the main goal is to entertain the reader (Primor et al., 2011; Sáenz & Fuchs, 2002). These texts include elements such as characters (who have their own goals and motives) and actions are organized in a temporal chain of events. By contrast, expository texts aim to communicate or inform the reader about something new due to this, content is connected through logical relations (Primor, et al., 2011). Materials such as textbooks or manuals are considered expository texts (Sáenz & Fuchs, 2002). Regarding the frequency of use of each text genre in school, it seems that children are mainly exposed to narrative texts in early grades of elementary school. For instance, as Duke (2000) signalled a mean of only 3.6 minutes per day was spent with informational/expository texts during classroom written language activities in first grade (even less time in low socioeconomic stratum classrooms). However, in later grades expository texts become the main source of academic knowledge (Kraal, et al., 2019).

Empirical findings in TH children and recent meta-analyses about the effect of text genre in both adults and children (Clinton et al., 2020; Mar et al., 2021) suggest that expository texts are more difficult to understand than narrative texts for several reasons. First, the structure and reading goals of expository texts are not as clear and familiar as those of narrative texts for young readers (McNamara et al., 2017; Lorch, 2017). Second, comprehension of expository texts is more influenced by readers' prior knowledge than comprehension of narrative texts (Best et al., 2008). Third, expository texts tend to introduce novel concepts or ideas so the vocabulary might be less familiar for the reader than in narrative texts (McNamara et al., 2017). Finally, these factors make it more difficult for the reader to draw inferences automatically (Lorch, 2017), especially for students with learning disabilities (Sáenz & Fuchs, 2002).

Reading comprehension as a function of text genre in participants who are DHH

Concerning DHH readers, we have only found two studies comparing narrative and expository texts (Figueroa et al., 2020). Figueroa et al. (2020) showed that adolescents with Cochlear Implants (CI) (N=36, M_{age}= 14.03) obtained significantly lower reading comprehension scores than a TH control group for both an expository and a narrative text. When the DHH group was split by age of implantation of the CI, the differences for both text types compared to the TH group remained only for the late implanted group. This finding seems to suggest that hearing age (associated with more language exposure) might be an important contributor to text comprehension regardless of text genre. However, this study did not directly compare the effect of text genre on each group of participants so it is only possible to conclude that groups were different in both genres as a function of reading age. Conversely, Banner and Wang (2011) used interviews and think-aloud procedures in which DHH participants (5 adults and 6 teenagers) were interrupted 3 times during the reading of a text to answer questions about their reading strategies. They found that participants reported using more reading strategies such as "Seeking answers in context to self-generated questions" or "Deciding what to skim or skip and what to read carefully" in a narrative text than in an expository text. If the premise that expository texts are more complex than narrative texts is correct, we could interpret this finding as a more efficient use of reading strategies (or self-regulation) in the easiest and more familiar narrative text structure. However, as noted, Banner and Wang did not measure comprehension accuracy but rather the process of reading by means of think-aloud procedures so we cannot make conclusions about the effect of text genre on accuracy. Next, we discuss the importance of measuring the reading process by means of eye-movements in order to have a complete picture of reading comprehension in both DHH and TH readers.

Eye-movements during text comprehension as a function of text genre in participants with typical hearing

The difficulty that the text poses in typical readers is reflected not only in global comprehension but also in several eye-movement measures. For example, in the case of TH adults and children, measures such as *average fixation duration* (sum of duration of all fixations divided by number of fixations in the text); *number of fixations*; *total fixation time for the text* (sum of the duration from all fixations in the text, known as *dwell time* if saccades are included in the computation) correlated with subjective ratings of the difficulty of the passages (Rayner et al., 2006). In this sense, the duration and number of fixations increases in difficult texts (e.g., average fixation duration for adults: M_{easy}=267 msec; $M_{\text{difficult}}$=270 msec; [Rayner et al., 2006]; for children: M_{easy}=268; $M_{difficult}$ =300 [Blythe et al., 2009]). *Saccade amplitude* (defined as the sum of all saccade amplitude divided by the number of saccades in the text where the amplitude is the distance from start to end point of the saccade) is between 7-9 letter spaces for typical adult readers (Rayner, 2009) and can also vary with text difficulty. In this way, as text difficulty increases, saccade amplitude decreases (for a review, see Rayner, 1998). Finally, *regressive fixations* (fixations preceded by regressive saccades that go backwards within the same word or area of interest before leaving it, or go back to a previous word or line of text that has been already visited [also called *revisits* in the latter case]) in comparison to *progressive fixations* (fixations preceded by progressive saccades that stay within the same word before leaving it or go to a subsequent word or line of text) can also appear as an indicator of effortful reading. As text difficulty increases the number of regressive fixations tends to increase, in many cases as an attempt to recover from comprehension failure (for a review, see Rayner, 1998 and Rayner et al., 2016).

Interestingly, text-related characteristics (such as text genre) and student-related characteristics might have an interactive effect on the time-course of text processing (de Leeuw et al., 2016a, 2016b). When text difficulty increases, readers need to invest more resources in terms of prior knowledge, vocabulary, inferencing abilities or metacognitive skills (that help the reader to detect, regulate and restore comprehension breaks). Indeed, in TH readers, Kraal et al. (2019) showed that reading proficiency influences the processing of texts of different genres. They registered the eye movements of 53 good comprehenders (GC) and 27 poor comprehenders (PC) (M_{age}=7:8) while they read two expository and two narrative texts. Their comprehension accuracy of each text was assessed by means of comprehension questions. They found that comprehension scores were higher for narrative texts than for expository texts in both groups, and GC students obtained higher scores than PC students. Regarding eye movements, they found that PC students made longer first pass fixations, skipped fewer words and made smaller saccades than GC students across text genres which suggested more careful or effortful processing for PC students in general. Although the effect was not statistically significant, the PC students also showed a tendency towards increased saccade amplitude in the expository texts that, according to the authors, would indicate that PC students adopted a less efficient or flexible processing strategy when facing texts of different difficulty (genre in this case) than GC students. We highlight this last non-significant result of Kraal et al. (2019) because, as we will see later, one of the results of the present study is consistent with this tendency.

Eye-movements during text comprehension as a function of text genre in participants who are DHH

In the particular case of students who are DHH, the literature has documented weaknesses in several domains related to literacy and reading proficiency in terms of discourse skills (Kyle & Cain, 2015; Marschark & Wauters, 2008; Strassman, 1992; see for a review Sullivan et al., 2020), prior knowledge (Convertino et al., 2014), vocabulary (Harris et al., 2017; Herman et al., 2019; Moreno-Pérez et al., 2015), and syntactic skills (Barajas et al., 2016; Gómez-Merino., 2020 and 2021). All of these findings suggest that the online reading pattern of DHH readers might differ from that of TH readers as a function of their reading proficiency and the type of text they are reading in a similar way that poor and good comprehenders with TH differ (Kraal et al., 2019). In fact, the results of Banner and Wang (2011) mentioned above showed that DHH participants reported using fewer reading strategies in expository than in narrative texts which coincides with the pattern of less efficient or flexible processing strategy by poor readers when facing texts of higher difficulty showed by Kraal et al. (2019). However, Banner and Wang did not use eye-movements but verbal protocols as a measure of the reading process.

In contrast, Bélanger et al. (2018) did measure eye-movements in DHH readers but found results which were inconsistent with Kraal et al.'s interpretation. Bélanger et al. (2018) examined the reading perceptual span children and adolescents (7 to 15 years old) who were DHH using the moving-window paradigm combined with eye-movements. In the moving-window paradigm some information in parafoveal vision (part of a text focused on the region of the retina surrounding the fovea which is up to 5 degrees from the foveal fixation point) is blocked (with a series of Xs or jumbled letters), preventing the access of information from the parafovea (see Rayner, 2014; Rayner & Morrison, 1981). The number of characters visible is manipulated (no window, 2, 6, 10, 14 or 18 characters in the Bélanger's study). The reading perceptual span is defined as the region in which readers use and process visual information in order to guide their eye movements. In the moving-window paradigm, this is operationalized as the window size at which normal reading speed is reached. They found that children and adolescents who are DHH (Bélanger et al., 2018) (as well as DHH adults [Bélanger et al., 2012; Bélanger & Rayner, 2015 for a review]): 1) showed a larger perceptual span than their reading-age TH peers (10 vs. 6 characters to the right of fixation respectively), and 2) made a similar number of regressions back into the sentence as their reading-age TH counterparts. Therefore, they could reach the same level of comprehension by making longer saccades and without needing to reread the text. The authors argued that these results confirmed that DHH readers were more efficient when attending to information allocated in the parafovea and could capture more visual information within a single fixation either due to auditory deprivation or to exposure to sign language. Note however that these effects were only observed in participants who used sign language as their preferred communication mode and to our knowledge this question remains unexplored for those who use spoken language as their unique mean of communication. Indeed, communication mode has affected the pattern of results in previous online studies with the deaf population (e.g., those studying the use of phonological codes during reading, see Blythe et al., 2018; Bélanger et al., 2013).

In summary, to date no studies have explored online reading comprehension in children with DHH using the whole text as the unit of analysis. According to Hyönä and Kaakinen (2019), the integrative processes required to build a coherent mental representation of a longer text are likely to increase rereading rate or saccade amplitude as compared to sentence reading (see Camblin et al., 2007 and Hyönä & Kaakinen, 2019, for review and discussion). Although the aim of the present study was not to compare sentence versus passage reading, we mention this issue to highlight a research gap in the reading and deafness literature that made us to focus on the whole text as unit of analysis.

In sum and turning to the issue of the influence of text genre in reading patterns, in general terms, DHH readers have been found to present a profile of poor comprehension. Therefore, if their performance is similar to that of TH poor comprehenders, we would expect that their eye movements during text reading would differ from those of TH adequate comprehenders. In particular, they would show fewer monitoring behaviour differences between text genre types than TH adequate comprehenders who would adapt their online processing strategies to the more demanding expository texts. These differences would be observed in the number and duration of regressive and progressive fixations, and in saccade amplitude. This study is the first to attempt a comprehensive analysis of reading comprehension as a function of text genre in DHH participants by measuring both, comprehension product and process. Examining the process of reading in students with deafness may help to identify exactly where and when reading comprehension breaks down, providing a better understanding of what might be the best focus of reading intervention practices. It is necessary to include the product of reading too in order to know if the eye-movements fluctuations correlate with higher or lower comprehension accuracy.

Aims of the Study

The present study examined comprehension accuracy and patterns of eye movements during reading of short texts in two groups: 1) children and adolescents who are deaf or hard of hearing (DHH); and 2) a chronological age matched control group with typically hearing (TH). Participants' eye movements were monitored while they read two short texts. Afterwards, they were asked to answer comprehension questions about what they had read. The effects of text genre (narrative versus expository) on comprehension accuracy and eye-movement patterns were analysed. Our predictions are detailed below.

Predictions

1. Global comprehension (called "accuracy" hereinafter):
    a. We expected that DHH participants would show lower comprehension accuracy than the TH participants (e.g., Barajas et al., 2016).
    b. We expected higher comprehension accuracy for narrative than for expository text for both groups (Best et al., 2008).
2. Eye-movement measures.
    a. In terms of whole text eye movements measures, we expected that reading times and number of fixations (especially regressive) would be higher and saccade amplitude shorter in the expository text than in the narrative text (Best et al., 2008; Rayner, 1998) as indicators of effortful reading.
    b. We also expected an interaction between hearing status and text genre such that, TH readers would slower reading (longer fixation time, shorter saccades and more fixations) in the expository text to adjust to its higher processing demands (Best et al., 2008; Rayner, 1998) but DHH participants' eye movements patterns would not differ across text genres (Kraal et al., 2019).

Method

Participants

Group of Students with Deafness (DHH)

Twenty-six (4th to 10th graders) DHH participants were recruited from different audiology services in public hospitals, mainstream schools with special units for deaf students and associations for deaf people in Valencia (Spain). Although Valencia is a bilingual region of Spain (Valencian and Spanish are the two official languages), Spanish had been one of the languages of instruction for all participants in primary and secondary schools. The tutors and parents of all participants were given information sheets and gave their explicit written consent. They also received a report of their results on the standardized tasks used in the study in order to thank them for their participation. There were four inclusion criteria for the participants of the DHH group: 1) Onset of bilateral hearing loss before the age of two years; 2) Severe to profound hearing loss according to Bureau International d'Audiophonologie's norms (BIAP, 1997); 3) Nonverbal IQ in the normal range (>=85) measured by the K-BIT test (Kaufman & Kaufman, 1997) and 4) Word decoding skills appropriate to their school year (less than 2SD below the average) measured by the word and non-word reading tasks of the PROLEC-R (Cuetos et al., 2007) and PROLEC-SE (Ramos & Cuetos, 1999) for Primary and Secondary respectively.

In addition, the exclusion criteria for this group were the presence of other sensorial deficits or co-morbid conditions. Therefore, of the total of 26 recruited participants, 7 of them were excluded: two because of diagnosed visual difficulties, two due to comorbidities (Usher Syndrome and Hydrocephaly), two because they were users of Spanish as a second language and one for being interrupted during the experiment.

Consequently, the final sample was composed of the remaining 19 students (11 girls; mean age 12.4 years, range 9.6-15.2). Although it was not an inclusion criterion, all of the participants had hearing parents and did not have knowledge of sign language. Eleven participants were users of cochlear implants, four of hearing aids and four of both types of hearing stimulation. See “Supplementary data” for details about audiological features of the sample (https://osf.io/8msx2/?view_only=c780391017b948129d1eb60eaef2a225).

Group of Students with Typical Hearing (TH)

A group of 19 typically hearing students from primary and secondary schools (11 girls; mean age 11.8 years, range 8.8-14.8) were recruited to take part in the study. Some of the participants were TH children who attended the same schools as the DHH participants; others were recruited from other mainstream schools in Valencia (Spain). As in the case of DHH participants, all TH participants had used Spanish as one of the instruction languages in primary and secondary schools. The students with TH were matched to the students with DHH on chronological age and nonverbal IQ following a group matching procedure. The differences between groups in these two measures were not significant as compared by using the t-student test for variables normally distributed measures and Mann Whitney U Test for non-normally distributed measures (see Table 1 for details). As can be seen in Table 1, the distribution by grade level was similar for the DHH and TH participants although it was not a matching criterion.

Background and Exclusion Criteria Assessment

In order to assess background levels in non-verbal reasoning, language and reading skills, a battery of tests was administered to both groups of participants. The test battery evaluated the following variables: non-verbal IQ (Matrices sub-scale of the Kaufman Brief Intelligence Test [K-BIT, Kaufman & Kaufman, 1997]), word and non-word reading accuracy and speed (Word and non-Word tasks of the Battery of Evaluation of Processes of Reading [Ramos & Cuetos, 1999; Cuetos et al., 2007] [primary or secondary level versions according to the school age of the participants]), written syntax (Syntactic Ability Test [SAT, Domínguez et al., 2013]), text comprehension (reading comprehension subtest of the Magallanes scale of Reading and Writing

TALE 2000 [Toro et al., 2000], note that this subtest was used to establish the reading comprehension level of students but the texts contained in it were different to the ones used as experimental texts), reading span (Spanish version of the Daneman and Carpenter's.,1980; Reading Span Test, Spanish adaptations for children and adolescents [Carriedo & Rucián, 2009; Elosúa et al., 1996]), receptive vocabulary (Peabody picture vocabulary test [Dunn et al., 2006]) and expressive language (Formulated Sentences from the CELF-4 [Semel et al., 2006]).

Material

Target Reading Task

In order to measure global text comprehension, we selected two of the four short texts which made up the reading comprehension subtest of the PROLEC-R Battery (Cuetos et al., 2007). The original subtest consists of four short texts in Spanish, two expository texts (short and long) and two narrative texts (short and long). As this experiment was part of a larger study, we selected the shortest version of each type of text in order to avoid fatigue effects. The same two texts were assigned to students regardless their reading level (in consistency with the manual instructions). The expository text contained 75 words (Content words=37 [49.3%]; Function words=38 [50.7%]) while the narrative text contained 94 words (Content words=42 ([44.7%]; Function words=52 [55.3%]). There were no significant differences between texts regarding average frequency ($U=3344$, z = - 0.57, p=.567, r=-.81), values (frequencies) obtained from the EsPal database [Duchon et al., 2013]), average number of characters per word (U = 3331, z = - 0.62, p = .533, r = - .44), average number of syllables per word ($U=3382, z=- 0.49, p=.625, r=-.35$) nor rate of function versus content words that composed each text (χ^2 (1, 169) = .60, p = .439).

In order to ensure that participants started to read the text from the beginning, a fixation cross located above the left upper corner of the texts preceded each text. The text was automatically presented when the participant fixated the cross for one second. After reading each text, participants were asked to answer four open questions which were presented in text format and read aloud by the evaluator. The order of presentation of the two texts was not counterbalanced in our study, the narrative was always presented before expository text as indicated in the instructions of the original standard test. The maximum score per text was four points, that is, participants could obtain a maximum score of 8 points. Although the texts were constructed to be appropriate for 1st to 6th graders, we considered the material would be appropriate for our sample given the expected low reading comprehension levels in DHH students.

Apparatus

Texts and comprehension questions were presented on a monitor with a screen resolution of 1366 * 768. A portable SMI-eye-tracker with a sampling rate of 60 Hz was used to record the students' eye movements (as used in previous reading studies with children with and without developmental disabilities [e.g. Davidson & Weismer, 2017; Khelifi et al., 2019]). Students sat in front of the monitor ensuring a testing distance of 60 cm. A chin-rest was used in order to minimize head movements. Texts were presented centered in black, 28 pt, Courier New font, on a light grey background. The lines were double spaced to prevent overlaps between fixations in the vertical axis. Although viewing and recording were binocular only data from the right eye were analysed. A nine-point calibration procedure was used before the reading task and as needed during the session. The researcher monitored the calibration and stimuli presentation from a laptop connected to display monitor by means of the iView X™ and Experiment center software.

Procedure

Ethical approval was obtained from the University of Valencia Committee for Research and from a collaborating hospital; the name of the hospital is not revealed in order to preserve the anonymity of the participants. Participants were tested in a quiet room in their school, home or in some cases in the eye-tracking laboratory of at the University of Valencia. All instructions were provided orally and in written form to ensure that hearing status did not interfere with the comprehension of the tasks. The study was completed in two or three sessions, and the procedure was as follows: First, the parents signed the consent forms and then the offline tasks (except for the reading span and word decoding tasks) were administered. It was not possible to counterbalance the order of presentation of tasks across participants as on most of the occasions it was necessary to adapt the administration of the tasks to the time availability of participants. This was the case especially when testing took place at the educational settings. Therefore, this first assessment took up to two sessions. Each session included at least one short break and lasted 50-60 minutes. Following this, the participants were given an appointment for the final session. During this session, the experimental task and two off-line tasks (the reading span and word decoding tasks) were administered. Students also completed two more experimental tasks as part of a larger study: these experimental tasks were administered in the same order to all participants. The final session lasted approximately 50 minutes.

For the experimental task, the procedure was arranged in line with the PROLEC-R manual instructions. Participants were asked to read the two texts silently and indicate orally when they had finished reading. Their eye movements were monitored throughout passage reading but not during question answering. Once they finished each text, the four questions were presented in written form on the screen and the participants gave an oral answer to them.

Results

Background Assessment

Participants in the TH group outperformed participants of the DHH group in word reading speed, text comprehension, expressive language and vocabulary level but groups were similar for the other background variables (see Table 1 for details and "Supplementary data" for individual scores in each test).

< Table 1 over here >

Text Comprehension: Accuracy

As a measure of text comprehension accuracy, we used the percentage of correct answers which was analysed by means of a Linear Mixed Model using the lmer function in R (R Core Team, 2019). Group and text genre were introduced as categorical fixed factors. Effect coding was used following a 0.5/-0.5 coding scheme (Group, DHH = 0.5 vs. TH = - 0.5; Genre, Expository = 0.5 vs. Narrative = - 0.5). To model for individual differences within each group, the intercept for participants was introduced as the only random effect in the model with the following syntax:

*lmer(depvar~group*genre+(1|participant), data = data)*

This way, participants had their own baseline values. The random intercept for items was not introduced because there was just one item per condition at the whole text level. Following the standard in the field, effects were considered significant at the .05 alpha level if the reported (absolute) *t* values were equal to or greater than 1.96 (e.g. Bélanger et al., 2018). Means and standard deviations for each group and condition are shown in Table 2.

Confirming prediction 1a, the effect of hearing status was significant (*b*=-19.07, *t* = -2.99, *p = .005*) with the DHH group obtaining a lower percentage of correct answers (*M* = 57.9) than the TH group (*M* = 76.97). However, neither the main effect of text genre (*b*=-9.87; t = -1.81, *p* <. 078) nor the interaction group by text genre (*b*=14.47, *t* =1.39, *p = .173*) were significant. Therefore, prediction 1b regarding the effect of text genre on comprehension was not supported.

Eye Movements

Fixations shorter than 80 ms and longer than 1200ms were excluded from the data set (following Joseph et al., 2015). For the analysis of text genre effect, the whole text was considered as a single area of interest. Based on previous literature on discourse processing (Rayner, 2009; Rayner et al., 2006), the following measures were considered for this area (already described in the "Introduction" section): dwell time, average fixation duration, percentage of regressive fixations, percentage of progressive fixations and mean saccade amplitude (expressed in degrees of visual angle and characters). Except for the percentage measures, variables were averaged per character in order to control for text length which was longer in the case of the narrative text (narrative text=375 characters versus expository text=325 characters).

Per each eye movement measure, a Linear Mixed Model was computed with the lmer function ('lme4' R package). Protocols for fitting random and fixed factors were similar to the accuracy model's protocols. More details of random and fixed effects' models are provided in "Supplementary Data". When variables were not normally distributed, they were log-transformed which resulted in more normal distributions. However, for ease of interpretation, Table 2 shows untransformed means (M) and standard deviations (*SD*s) for both measures averaged per characters and measures non-averaged per characters. Non-averaged descriptive data showed that the dwell fixation time (sum of the duration of fixations and saccades) was around 34 seconds per text. Participants made around 100 fixations per text, 80% of which were progressive fixations with 20% regressive fixations. These proportions are similar to those seen in previous studies (e.g., Joseph et al., 2009; Kraal et al., 2019). The average fixation duration per word was 280 ms, and the average saccade amplitude, around six letters, again consistent with previous eye movement studies.

< Table 2 over here >

In terms of eye movements measures, we expected (prediction 2a) that reading times and number of fixations (especially regressive) would be higher and saccade amplitude shorter in the expository text than in the narrative text (Best et al., 2008; Rayner, 1998) as indicators of effortful reading. The results showed, that the effect of text genre on the percentage of regressive fixations was significant ($b = 2.38$, t = -2.39, $p = .022$), as it was on the percentage of progressive fixations ($b = -2.38$, t = 2.37, $p = .023$), dwell time ($b = 17.66$, $t = 4.93$, $p > .001$) and saccade amplitude ($b = 0.001$, $t = -4.8$, $p < .001$). The effect of text genre was not significant in average fixation duration per character ($b = -2.98$, $t = 1.145$, $p < .252$). Note that *b* values for time and percentage measures reported here were calculated with untransformed variables to ease the interpretation, but *t* and *p* values correspond to transformed data (following Joseph et al., 2015 or Breadmore & Carroll, 2018). On average, participants spent longer and made more regressive fixations in the expository than the narrative texts, which confirms our prediction 2a for these measures. However, participants made significantly more progressive fixations in the narrative than in expository text which seems to suggest that reading was more linear in the narrative text but they also made shorter saccades in the narrative than in expository text which is not consistent with prediction 2a (longer saccades in the expository text to adjust to its higher processing demands, Best et al., 2008; Rayner, 1998). However, it is worth noting that text genre and hearing status interacted for saccade amplitude, so we will qualify this last result and its interpretation below.

The effect of hearing status was not significant for any eye-movement measure: dwell time (b = 11.94, t = 0.69, p = .495), average fixation duration (b = - 1.76, t = 0.21, p = .834), percentage of progressive fixations (b = -1.10, t = -0.56, p = .576), percentage of regressive fixations (b = 1.10, t = 0.56, p = .576), and saccade amplitude (b = 0.001, t = - 0.195, p = .847).

According to prediction 2b, we expected an interaction between hearing status and text genre, such that, TH readers would slow down (longer fixation time, shorter saccades and more fixations) in the expository text to adjust to its higher processing demands (Best et al., 2008; Rayner, 1998) but DHH participants' eye movements patterns would be more similar across text genres (Kraal et al., 2019). However, the interaction between hearing status and text genre was only significant for saccade amplitude (b = 0.001, t = - 2.44, p = .020) but not for the rest of variables: dwell time (b = - 2076, t = 0.18, p = .960), average fixation duration (b = -3.39, t =1.19, p = .234), progressive fixations (b = - 1.26, t = 0.65, p = .521) and regressive fixations (b = 1.26, t = 0.65, p = .521). Furthermore, the interaction between text genre and group in the case of saccade amplitude was in the opposite direction to that expected since the analysis of simple effects (using the test *Interactions* function of the phia R package [De Rosario-Martínez, 2015]) showed that the effect of text genre was significant for DHH participants (χ^2 = 26.25; p < .001, with Bonferroni correction) but not for TH participants (χ^2 = -12.03; p = .191, with Bonferroni correction) such that only DHH participants showed longer saccade amplitude in the expository than the narrative texts (see Figure 1). This result is not consistent with our predictions that saccade amplitude would be longer in narrative than expository texts (2a) and that we would see similar eye movement patterns across text genres for DHH participants (2b). In other words, this interaction between text genre and group for saccade amplitude is not consistent with our prediction for TH readers who showed no signs of monitory adjustment in the more difficult expository test nor for DHH readers who showed shorter saccade amplitude or monitory adjustment in the *a priori* easier narrative text.

< Figure 1 over here >

Discussion and Conclusions

The well-documented gap between DHH and TH children and adolescents in reading comprehension performance (Geers et al., 2008; Harris & Terlektsi, 2011; Traxler, 2000) may have started to attenuate recently thanks to early educative and medical interventions and refined assessment instruments (Easterbrooks & Beal-Alvarez, 2012; Figueroa et al., 2020). Reducing this gap is essential in primary and secondary schools where texts are still one of the main sources of knowledge and learning.

In order to gain a better understanding of reading proficiency in DHH children and adolescents, the present study aimed to explore the effect of text genre (narrative vs. expository) on the comprehension accuracy and eye-movement patterns of DHH and TH students as they read texts for comprehension.

Conclusions about the effect of text genre in comprehension accuracy

Regarding comprehension accuracy, we expected that DHH participants would show poorer performance than TH participants (prediction 1a) and that both groups would obtain higher comprehension accuracy in narrative than in expository texts (prediction 1b). Our results only partially confirmed these predictions as comprehension accuracy was significantly lower in

DHH students than in TH students but it was similar across text genres for both DHH and TH. The main effect of hearing status seems to be consistent with the findings of Figueroa et al. (2020), the only previous research in which the reading product of groups of students with and without hearing loss were compared using narrative and expository texts, who showed that adolescents with TH outperformed adolescents with deafness and CIs not only in expository but also in narrative texts. However, Figueroa et al. found these results only for the sub-group of late implanted participants so it seems that hearing age may better explain differences in global reading comprehension. We did not have sufficient sample size as to examine the effect of hearing age in our current study but we hope that future studies can examine this possibility. Another way of approaching this type of analysis is by aggregating data from different laboratories so in order to facilitate data aggregation, we have made available the details about audiological features of our sample in "supplementary data" (https://osf.io/8msx2/?view_only=c780391017b948129d1eb60eaef2a225). Actual disaggregated accuracy and eye movements data during the reading comprehension task have also made available in this repository.

Conclusions about the effect of text genre in eye-movement measures

Regarding eye-movement measures, and, before discussing the results regarding our particular research questions, it is important to highlight some important results for the global measures that seem to converge with previous research in children and adult readers with TH. The descriptive data showed that reading was mainly linear and that proportions of regressive and progressive fixations were similar to those seen in previous studies (e.g., Blythe et al., 2009; Kraal et al., 2019). The average fixation duration per word was 280 ms, and the average saccade amplitude, around six letters (in line with previous literature with population with typical hearing; e.g., Blythe et al, 2011 [for a review]; Joseph et al., 2009; Rayner, 2009; Rayner et al., 2006).

In relation to the effect of text genre on the eye-movement patterns in our two groups, we expected that reading time (global text dwell and average fixation duration), and number of fixations (especially regressive) would be higher and saccade amplitude would be smaller in the expository text than in the narrative text (prediction 2a). Partially confirming this prediction, both DHH and TH participants showed longer dwell times and made more regressive fixations in the expository text than in the narrative text. Both groups made more progressive fixations in the narrative than in the expository text which suggests that reading was more linear in this condition. However, for saccade amplitudes, we found an interaction between hearing status and text genre that was inconsistent with our research questions (2a and 2b). Indeed, prediction 2b anticipated an interaction between hearing status and text genre such that the effect of text genre would be higher for TH participants than for DHH participants as TH readers were expected to slow down in expository texts to adjust to their higher processing demands (Best, et al., 2008) while for DHH participants both expository and narrative texts would be similarly demanding. Instead, we found that DHH participants showed longer saccade amplitudes in the expository than in the narrative texts in comparison with TH participants, who showed no significant differences between genres.

The longer saccade amplitude in expository texts could be interpreted as evidence that DHH readers adopt a more careless or effortless reading strategy because either they did not detect the difficulty of the expository text or they did not have sufficient resources to adjust to it, so it could reflect a lack of reading monitoring strategies (see Kraal et al., 2019). Indeed, this result is somewhat consistent with the results of Banner and Wang (2011) who found that deaf adults were able to report the usage of more reading strategies in narrative than in expository texts which means that they seemed to self-regulate better in the easiest and more familiar narrative text structure. Also, this result seems to agree with Kraal et al. (2019) who found that students with poor comprehension made smaller saccades in the narrative texts than better comprehending students (suggesting more careful or effortful processing) and increased saccade amplitude in the expository text. We did base our prediction on Kraal et al. (2019)'s findings because as they acknowledge, this effect was not statistically reliable. It is also possible that as participants with DHH's reading difficulties were associated with poor linguistic (vocabulary) knowledge and as such, they may have not known the meaning of many words in the expository text and so they did not try to adapt their reading according to the text demands.

A final remark about saccade length, and in particular, forward saccade length is that it would also serve as a useful measure of how much information is included within one fixation as it is related to the extrafoveal distribution of visual attention (Rayner, 1998). In this way, longer saccade lengths would mean that readers are extracting more information per fixation or in other words, that they have a higher perceptual span. If we accept this premise, it would mean that our DHH participants were extracting more information during each fixation in the expository texts than in the narrative. However, their comprehension scores in the expository text were similar to those in the narrative text so this enhanced perceptual span is not improving global comprehension.

Another interesting finding is that in our study, the average saccade amplitude was around six letters which as, we have already noted, is in line with some previous literature in typical readers (e.g., Blythe & Joseph, 2011 [for a review]; Blythe et al., 2009; Rayner, 2009; Rayner et al., 2006) but differ from the enhanced perceptual span found by Bélanger et al., 2018) in participants with DHH (10 characters to the right of fixation). Clearly there are many methodological differences between our study and that of Bélanger et al. that should be considered when interpreting this lack of consistency. In particular, most of Bélanger et al. participants with DHH were experienced users of sign language while our participants with DHH were users of oral language and reported no knowledge of the sign language, so consequently, their perceptual span may have been enhanced due to the experience with a visuo-spatial language such as sign language.

Our eye-movement results make a significant contribution to the field through its focus on reading comprehension of whole texts as unit of analysis in children and adolescents who are DHH despite limitations in sample size and the unpredicted pattern of effects. As we noted earlier, this type of reading material (texts) requires different processing resources to the reader than disconnected words or sentences (e.g. Camblin et al., 2007; Hyönä & Kaakinen, 2019) and are of enormous ecological validity for children and adolescent with deafness as texts are the main source of knowledge in Primary and Secondary school. Future research should explore passage reading in this population to examine outstanding questions (e.g. role of hearing status or communication mode preferences).

Methodological limitations and future directions

Finally, we wanted to mention some methodological limitations, some of them already noted, that might compromise the generalization of our results and could be considered in future research. Firstly, as it is often the case in research with special populations, the sample size is quite small, especially when a homogeneous disability group regarding some key criteria is sought (such as regular non-verbal IQ or decoding skills in this case). Our small sample size may have increased the probability of committing type II errors by failing to reveal differences between hearing status groups on the eye-movement' measures that might be present. Second, the order of presentation of the two texts was not counterbalanced in our study (narrative was always presented before expository text). A possible consequence of this fixed order is that the text genre effects on comprehension accuracy and eye-movement' patterns might be the result of fatigue or familiarity with the procedure as Kraal et al. (2019) highlighted for their own research where a fixed text genre order was also used. However, the advantage of the fixed order was to be consistent with the procedure recommended by the original standardized test from which the texts were extracted (PROLEC-R reading battery, Cuetos et al., 2007). In addition, as the narrative text was actually expected to be easier than the expository text, we expected this might motivate readers to keep engaged in the task. The last limitation we want to mention is that there was just one text by genre condition so the effects could be due to particularities of the texts used and not to the genre itself and, again, the fact that there were just two items might cause that statistical analyses are potentially underpowered. Future research should include a higher number of texts per condition.

Applied conclusions

Reading longer texts, both narrative and expository, becomes increasingly important as children progress through the education system and indeed becomes the main source of academic knowledge in high school. Our data support previous studies that suggests that educators should be aware that differences between DHH and TH students are related not only to comprehension accuracy but also to the amount of resources that they need to invest during text processing. Teaching text structure as part of more comprehensive literacy programs (e.g. Wang & Paul, 2011), especially for expository texts, to DHH students as a way of facilitating comprehension monitoring (Arfé et al., 2018; Williams et al., 2004; Hall et al., 2005; Akhondi et al., 2011) is already recommended and our data are consistent with this recommendation. Indeed, explicit teaching of text structure might help students better anticipate, predict and consequently monitor their understanding of a text. For instance, if students know the expository structure of a text by means of a graphic organizer they might anticipate what to skim or skip and what to read carefully or seek answer to teacher or self-generated questions. In this regard, in a meta-analysis of the effects of expository text structure interventions on comprehension, Pyle et al. (2017) concluded that most expository text structure interventions often included modelling and corrective feedback, contrasting cases, the use of graphic organizers and especially adapting and scaffolding text structure instruction (e.g., using more complex expository texts as students improve their use of the text structure strategy). When the instruction is personalized to students' level of performance, the combination of product and process (e.g. eye-movements) measures of comprehension might result specially well suited to a fine-grained classification of students' levels.

Finally, as Duke (2000) recommended in his preliminary research about text genre, not only explicit teaching but just the presence of different types of text genres other than stories should be increased in curricula from early grades, especially for those students at risk of delays or failures in reading comprehension, such as students who are DHH. Note, however, that we did not explore the use or effect of this kind of interventions in the current study so we encourage researchers to do it in the future.

Funding

[Information provided at the "Tittle page"]

Acknowledgments

[Information provided at the "Tittle page"]

References

Akhondi, M., Malayeri, F. A., & Samad, A. A. (2011). How to teach expository text structure to facilitate reading comprehension. *The Reading Teacher, 64(*5), 368–372. https://doi.org/10.1598/RT.64.5.9

Arfé, B., Mason, L., & Fajardo, I. (2018). Simplifying informational text structure for struggling readers. *Reading and Writing,31*(9), 2191-2210. https://doi.org/10.1007/s11145-017-9785-6

Banner, A., & Wang, Y. (2011). An analysis of the reading strategies used by adult and student deaf readers. *Journal of Deaf Studies and Deaf Education, 16*(1), 2–23. https://doi.org/ 10.1093/deafed/enq027

Barajas, C., González-Cuenca, A. M., & Carrero, F. (2016). Comprehension of texts by deaf elementary school students: The role of grammatical understanding. *Research in Developmental Disabilities, 59*, 8–23. https://doi.org/10.1016/j.ridd.2016.07.005

Bélanger, N. N., Lee, M., & Schotter, E. R. (2018). Young skilled deaf readers have an enhanced perceptual span in reading. *Quarterly Journal of Experimental Psychology*, *71*(1), 291–301. https://doi.org/10.1080%2F17470218.2017.1324498

Bélanger, N. N., Mayberry, R. I., & Rayner, K. (2013). Orthographic and phonological preview benefits: Parafoveal processing in skilled and less-skilled deaf readers. *Quarterly Journal of Experimental Psychology*, *66*(11), 2237-2252. https://doi.org/10.1080/17470218.2013.780085

Bélanger, N. N., & Rayner, K. (2015). What eye movements reveal about deaf readers. *Current directions in psychological science*, *24*(3), 220-226. https://doi.org/10.1177/0963721414567527

Bélanger, N. N., Slattery, T. J., Mayberry, R. I., & Rayner, K. (2012). Skilled deaf readers have an enhanced perceptual span in reading. *Psychological science*, *23*(7), 816-823. https://doi.org/10.1177/0956797611435130

Best, R. M., Floyd, R. G., & McNamara, D. S. (2008). Differential competencies contributing to children's comprehension of narrative and expository texts. *Reading Psychology, 29*(2), 137–164. https://doi.org/10.1080/02702710801963951

Blythe, HI, Dickins, JH, Kennedy, CR, Liversedge, S.P. (2018). Phonological processing during silent reading in teenagers who are deaf/hard of hearing: an eye movement investigation. *Developmental Science*, *21*(5), 1-19. https://doi.org/10.1111/desc.12643

Blythe, H. I., & Joseph, H. S. (2011). Children's eye movements during reading. In S. P. Liversedge, I. D. Gilchrist & S. Everling (Eds.), *The Oxford Handbook of Eye Movements* (p. 643–662) Oxford University Press.

Blythe, H. I., Liversedge, S. P., Joseph, H. S., White, S. J., & Rayner, K. (2009). Visual information capture during fixations in reading for children and adults. *Vision research, 49*(12), 1583–1591. https://doi.org/10.1016/j.visres.2009.03.015

BIAP (Bureau International d'Audiopnologie) (1997). *Recomendaciones del BIAP* (Comité Español de Audifonología, trad.). Madrid: Comité Español de Audiofonología.

Breadmore, H. L., & Carroll, J. M. (2018). Sublexical and syntactic processing during reading: evidence from eye movements of typically developing and dyslexic readers. *Journal of Cognitive Psychology*, *30*(2), 177–197. https://doi.org/10.1080/20445911.2017.1414222

Camblin, C. C., Gordon, P. C., & Swaab, T. Y. (2007). The interplay of discourse congruence and lexical association during sentence processing: Evidence from ERPs and eye tracking. *Journal of Memory and Language*, *56*(1), 103-128. https://doi.org/10.1016/j.jml.2006.07.005

Carriedo, N., & Rucián, M. (2009). Adaptation of Daneman and Carpenter's Reading Span Test (PAL-N) for children. *Journal for the Study of Education and Development, 32*(3), 449–465. https://doi.org/10.1174/021037009788964079

Clinton, V., Taylor, T., Bajpayee, S., Davison, M. L., Carlson, S. E., & Seipel, B. (2020). Inferential comprehension differences between narrative and expository texts: A systematic review and meta-analysis. *Reading and Writing, 33*(9), 2223–2248. https://doi.org/10.1007/s11145-020-10044-2

Convertino, C., Borgna, G., Marschark, M., & Durkin, A. (2014). Word and world knowledge among deaf learners with and without cochlear implants. *Journal of Deaf Studies and Deaf Education*, *19*(4), 471–483. https://doi.org/10.1093/deafed/enu024

Cuetos, F., Rodríguez, B., Ruano, E., & Arribas, D. (2007). *Batería de evaluación de los procesos lectores. Revisada (PROLEC-R)*. Madrid: TEA.

Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior, 19*(4), 450–466. Retrieved from https://search.proquest.com/docview/1297349869?accountid=14777

Davidson, M. M., & Weismer, S. E. (2017). Reading comprehension of ambiguous sentences by school-age children with autism spectrum disorder. Autism Research, 10(12), 2002–2022. https://doi.org/10.1002/aur.1850

Duke, N. K. (2000). 3.6 minutes per day: The scarcity of informational texts in first grade. *Reading research quarterly, 35*(2), 202-224. https://doi.org/10.1598/RRQ.35.2.1

Duke, N. K., Pearson, P. D., Strachan, S. L., & Billman, A. K. (2011). Essential elements of fostering and teaching reading comprehension. *What research has to say about reading instruction*, *4*, 286-314.

de Leeuw, L., Segers, E., & Verhoeven, L. (2016a). The effect of student-related and text-related characteristics on student's reading behaviour and text comprehension: An eye movement study. Scientific Studies of Reading, 20(3), 248–263. https://doi.org/10.1080/10888438.2016.1146285

de Leeuw, L., Segers, E., & Verhoeven, L. (2016b). Role of text and student characteristics in real-time reading processes across the primary grades. *Journal of Research in Reading, 39*(4), 389–408. https://doi.org/10.1111/1467-9817.12054

De Rosario-Martínez, H. (2015). Phia Post-Hoc Interaction Analysis (Version 0.2-1) [Software package] Retrieved from https://CRAN.R-project.org/package=phia

Domínguez, A. B., Alegría, J., Carrillo, M. S., & Soriano, J. (2013). *PEALE. Pruebas de Evaluación Analítica de Lengua Escrita*. Universidad de Salamanca (Número de asiento registral: 00/2013/4067)

Duchon, A., Perea, M., Sebastián-Gallés, N., Martí, A., & Carreiras, M. (2013). EsPal: One-stop shopping for Spanish word properties. *Behavior Research Methods*, *45*(4), 1246–1258. https://doi.org/10.3758/s13428-013-0326-1

Dunn, L. M., Dunn, L., & Arribas, D. (2006). *PPVT- III Peabody, Test de Vocabulario en Imágenes*. Madrid: TEA Ediciones.

Easterbrooks, S. R., & Beal-Alvarez, J. (2012). States' reading outcomes of students who are d/deaf and hard of hearing. *American Annals of the Deaf*, *157*(1), 27–40. Retrieved from http://www.jstor.org/stable/26235186

Elosúa, M. R., Gutiérrez, F., Madruga, J. A. G., Luque, J. L., & Gárate, M. (1996). Adaptación española del «Reading span test» de Daneman y Carpenter. *Psicothema*, *8*(2), 383–395.

Figueroa, M., Darbra, S., & Silvestre, N. (2020). Reading and Theory of Mind in Adolescents with Cochlear Implant. *The Journal of Deaf Studies and Deaf Education, 25*(2), 212–223. https://doi.org/10.1093/deafed/enz046

Geers, A., Tobey, E., Moog, J., & Brenner, C. (2008). Long-term outcomes of cochlear implantation in the preschool years: From elementary grades to high school. International *Journal of Audiology*, *47*(sup2), S21–S30. https://doi.org/10.1080/14992020802339167

Gómez-Merino, N., Fajardo, I., & Ferrer, A. (2021). Did the three little pigs frighten the wolf? How deaf readers use lexical and syntactic cues to comprehend sentences. *Research in Developmental Disabilities*, *112*, 103908. https://doi.org/10.1016/j.ridd.2021.103908

Gómez-Merino, N., Fajardo, I., Ferrer, A., & Arfé, B. (2020). Time-Course of Grammatical Processing in Deaf Readers: An Eye-Movement Study. *The Journal of Deaf Studies and Deaf Education, 25*(3), 351-364. https://doi.org/10.1093/deafed/enaa005

Hall, K. M., Sabey, B. L., & McClellan, M. (2005). Expository text comprehension: Helping primary-grade teachers use expository texts to full advantage. *Reading psychology*, *26*(3), 211–234. https://doi.org/10.1080/02702710590962550

Harris, M., & Terlektsi, E. (2011) Reading and spelling abilities of deaf adolescents with cochlear implants and hearing aids. *The Journal of Deaf Studies and Deaf Education*, *16* (1), 24–34. https://doi.org/10.1093/deafed/enq031

Harris, M., Terlektsi, E., & Kyle, F. E. (2017). Concurrent and longitudinal predictors of reading for deaf and hearing children in primary school. *The Journal of Deaf Studies and Deaf Education, 22*(2), 233–242. https://doi.org/10.1093/deafed/enw101

Herman, R. E., Kyle, F., & Roy, P. (2019). Literacy and phonological skills in oral deaf children and hearing children with a history of dyslexia. *Reading Research Quarterly, 54*(4), 553–575. https://doi.org/10.1002/rrq.244

Hyönä, J., & Kaakinen, J. K. (2019). Eye movements during reading. In *Eye Movement Research* (pp. 239-274). Springer, Cham.

Joseph, H. S., Liversedge, S. P., Blythe, H. I., White, S. J., & Rayner, K. (2009). Word length and landing position effects during reading in children and adults. *Vision Research, 49*(16), 2078–2086. https://doi.org/10.1016/j.visres.2009.05.015

Joseph, H. S., Nation, K., & Liversedge, S. P. (2013). Using eye movements to investigate word frequency effects in children's sentence reading. *School Psychology Review, 42*(2), 207–222. https://doi.org/10.1080/02796015.2013.12087485

Joseph, H. S. S. L., Bremner, G., Liversedge, S. P., & Nation, K. (2015). Working memory, reading ability and the effects of distance and typicality on anaphor resolution in children. *Journal of Cognitive Psychology, 27*(5), 622–639. https://doi.org/10.1080/20445911.2015.1005095

Kaufman, A. S., & Kaufman N. L. (1997). *Test Breve de Inteligencia de Kaufman*. Madrid: TEA Ediciones.

Khelifi, R., Sparrow, L., & Casalis, S. (2019) Is a Frequency Effect Observed in Eye Movements During Text Reading? A Comparison Between Developing and Expert Readers, *Scientific Studies of Reading*, *23*(4), 334–347. https://doi.org/10.1080/10888438.2019.1571064

Kraal, A., van den Broek, P. W., Koornneef, A. W., Ganushchak, L. Y., & Saab, N. (2019). Differences in text processing by low-and high-comprehending beginning readers of expository and narrative texts: Evidence from eye movements. *Learning and Individual Differences, 74*, 1–14. https://doi.org/10.1016/j.lindif.2019.101752

Kyle, F. E., & Cain, K. (2015). A comparison of deaf and hearing children's reading comprehension profiles. *Topics in Language Disorders*, *35*(2), 144–156. https://doi.org/10.1097/TLD.0000000000000053

Lorch Jr. R. F. (2017). What is so difficult about expository text? In J. A. León & I. Escudero (Eds.), *Reading Comprehension and Educational Settings* (pp. 145–167). Amsterdam, Netherlands: John Benjamins.

Mar, R. A., Li, J., Nguyen, A. T., & Ta, C. P. (2021). Memory and comprehension of narrative versus expository texts: A meta-analysis. *Psychonomic Bulletin & Review*, 1-18. https://doi.org/10.3758/s13423-020-01853-1

Marschark, M., & Wauters, L. (2008). Language comprehension and learning by deaf students. In M. Marschark, & P. C. Hauser (Eds.), *Perspectives on deafness. Deaf cognition: Foundations and outcomes* (pp. 309–350). New York, NY: Oxford University Press.

McNamara, D. S., Ozuru, Y., & Floyd, R. G. (2017). Comprehension challenges in the fourth grade: The roles of text cohesion, text genre, and readers' prior knowledge. *International Electronic Journal of Elementary Education*, *4*(1), 229–257. Retrieved from https://www.iejee.com/index.php/IEJEE/article/view/222

Moreno-Pérez, F. J., Saldaña, D., & Rodríguez-Ortiz, I. R. (2015). Reading efficiency of deaf and hearing people in Spanish. *Journal of Deaf Studies and Deaf Education*, *20*(4), 374–384. https://doi.org/10.1093/deafed/env030

Primor, L., Pierce, M. E. & Katzir, T. (2011). Predicting reading comprehension of narrative and expository texts among Hebrew-speaking readers with and without a reading disability. *Annals of Dyslexia*, *61*, 242–268. https://doi.org/10.1007/s11881-011-0059-8

Pyle, N., Vasquez, A. C., Lignugaris/Kraft, B., Gillam, S. L., Reutzel, D. R., Olszewski, A., Segura, H., Hartzheim, D., Laing, W., & Pyle, D. (2017). Effects of expository text structure interventions on comprehension: A meta-analysis. *Reading Research Quarterly*, *52*(4), 469-501. https://doi.org/10.1002/rrq.179

R Core Team (2019). R: A language and environment for statistical computing (Version 3.6.1) [Software package]. R Foundation for Statistical Computing. Vienna, Austria. Retrieved from https://www.R-project.org/.

Ramos, J., & Cuetos, F. (1999). *Evaluación de los Procesos Lectores en Alumnos de Tercer Ciclo de Educación Primaria y ESO (PROLEC-SE).* Madrid: TEA Ediciones.

Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin*, *124*(3), 372–422.

Rayner, K. (2009). Eye movements and attention in reading, scene perception, and visual search. *The Quarterly Journal of Experimental Psychology, 62*(8), 1457–1506. https://doi.org/10.1080/17470210902816461

Rayner, K. (2014). The gaze-contingent moving window in reading: Development and review. *Visual Cognition*, *22*(3-4), 242-258. https://doi.org/10.1080/13506285.2013.879084

Rayner, K., Chace, K. H., Slattery, T. J., & Ashby, J. (2006). Eye movements as reflections of comprehension processes in reading. *Scientific Studies of Reading, 10*(3), 241–255. https://doi.org/10.1207/s1532799xssr1003_3

Rayner, K., & Morrison, R. E. (1981). Eye movements and identifying words in parafoveal vision. *Bulletin of the Psychonomic Society*, *17*(3), 135-138. https://doi.org/10.3758/BF03333690

Rayner, K., Schotter, E. R., Masson, M. E., Potter, M. C., & Treiman, R. (2016). So much to read, so little time: How do we read, and can speed reading help? *Psychological Science in the Public Interest*, *17*(1), 4–34. https://doi.org/10.1177/1529100615623267

Roy-Charland, A., Saint-Aubin, J., Klein, R. M, Lawrence, M. (2007). Eye movements as direct tests of the GO model for the missing-letter effect. *Perception & Psychophysics 69*, 324–337 (2007). https://doi.org/10.3758/BF03193753

Sáenz, L. M., & Fuchs, L. S. (2002). Examining the reading difficulty of secondary students with learning disabilities: Expository versus narrative text. *Remedial and Special Education*, *23*(1), 31–41. https://doi.org/10.1177/074193250202300105

Semel, E., Wiig, E. H., & Secord, W. A. (2006). *Clinical Evaluation of Language Fundamentals- Fourth Edition, Spanish*. Needham Heights, MA: The Psychological Corporation.

Strassman, B. K. (1992). Deaf adolescents' metacognitive knowledge about school-related reading. *American Annals of the Deaf*, *137*(4), 326–330. https:/doi.org/10.1353/aad.2012.0456

Sullivan, S., Oakhill, J., Arfé, B., & Gómez-Merino, N. (2020). Reading comprehension: A comparison of typically hearing and deaf or hard-of-hearing children. In S. Easterbrooks & H. Dostal (Eds.), *The Oxford handbook of deaf studies in literacy*. Oxford, England: Oxford University Press. https://doi.org/10.1093/oxfordhb/9780197508268.013.13

Toro, J., Cervera, M., & Urío, C. (2000). *Escalas Magallanes de Lectura y Escritura. EMLE TALE-2000*. Baracaldo, Vizcaya: COHS.

Traxler, C. B. (2000). The Stanford Achievement Test, 9th edition: National norming and performance standards for deaf and hard-of-hearing students. *Journal of Deaf Studies and Deaf Education*, *5*(4), 337–348. https://doi.org/10.1093/deafed/5.4.337

Wang, Y. & Paul, P.V. (2011). Integrating technology and reading instruction with children who are deaf or hard of hearing: The effectiveness of the Cornerstones Project. *American Annals of the Deaf, 156* (1), 56-68. https://doi.org/10.1353/aad.2011.0014

Williams, J. P., Hall, K. M., & Lauer, K. D. (2004). Teaching expository text structure to young at-risk learners: Building the basics of comprehension instruction. *Exceptionality*, *12*(3), 129–144. https://doi.org/10.1207/s15327035ex1203_2

Table 1

Means (M), Standard Deviations (SDs) and Significance Tests for Comparisons between DHH and TH Students in Demographic Variables and Background Measures.

Group	**DHH Group (*n*=19, 11 girls)**	**TH Group (*n*=19, 11 girls)**	**Comparisons between groups**			
Background measures	***M (SD)***	***M (SD)***	***t***	***U***	***p***	***r***
CA (years; months)	12.4 (1.73)	11.8 (1.77)	1.00		.322	.17
Non Verbal IQ_ (RS)	32.37 (3.47)	33.74 (4.95)	-0.99		.330	.16
Non Verbal IQ (SS)	103.16 (9.38)	107.84 (10.56)	-1.45		.157	-.23
Word Reading Accuracy (RS)	39.47 (0.90)	39.58 (0.61)		179.00	.958	-.01
Word Reading Accuracy (SS)	106.60 (8.38)	105.22 (10.93)		174.00	.849	-.03
Non Word Reading Accuracy (RS)	38.63 (1.61)	38.37 (1.64)		160.50	.546	-.10
Non Word Reading Accuracy (SS)	109.40 (9.66)	107.78 (7.56)		147.50	.334	-.16
Word Reading Speed (Sec)	34.11 (7.52)	28.68 (5.93)	2.47		.018	.38
Word Reading Speed (SS)	107.09 (10.99)	116.69 (6.58)		82.00	.004	-.47
Non Word Reading Speed (s)	47.74 (8.59)	50.95 (11.36)	-0.98		.332	-.16
Non Word Reading Speed (SS)	111.47 (10.37)	112.54 (9.09)	-0.34		.737	-.06
Text Reading Comprehension (SS)	89.47 (17.50)	104.83 (6.59)		69.00	.001	-.53
Syntactic Ability Test [a]	43.21 (13.77)	52.00 (10.42)		116.50	.062	-.30
Expressive Language (RS)[b]	35.84 (8.28)	43.42 (5.54)		79.00	.003	-.48
Receptive Vocabulary (RS)	111.37 (25.05)	139.16 (14.27)		66.50	.001	-.54
Receptive Vocabulary (SS)	78.00 (20.82)	106.53 (8.55)		50.00	<.001	-.62
Reading Span (RS)	2.47 (1.01)	3.03 (0.63)		116.00	.054	-.31
School level (participants' frequency)						
3º-6º	9	11				
7º-8º	5	5				
9º-10º	5	3				

*Note.*CA= Chronological age; RS = Raw scores (number of correct answers); SS = standard score; s = seconds; *t* = *t* values; *U* = Man-Whitney U test value, *p* = *p* values.

[a] Scores from this test are computed in terms of correct answers with respect to the total test (Composed by 64 sentences)

[b] Raw scores are also presented for the expressive language sub-test (the maximum score could be 52)

Table 2

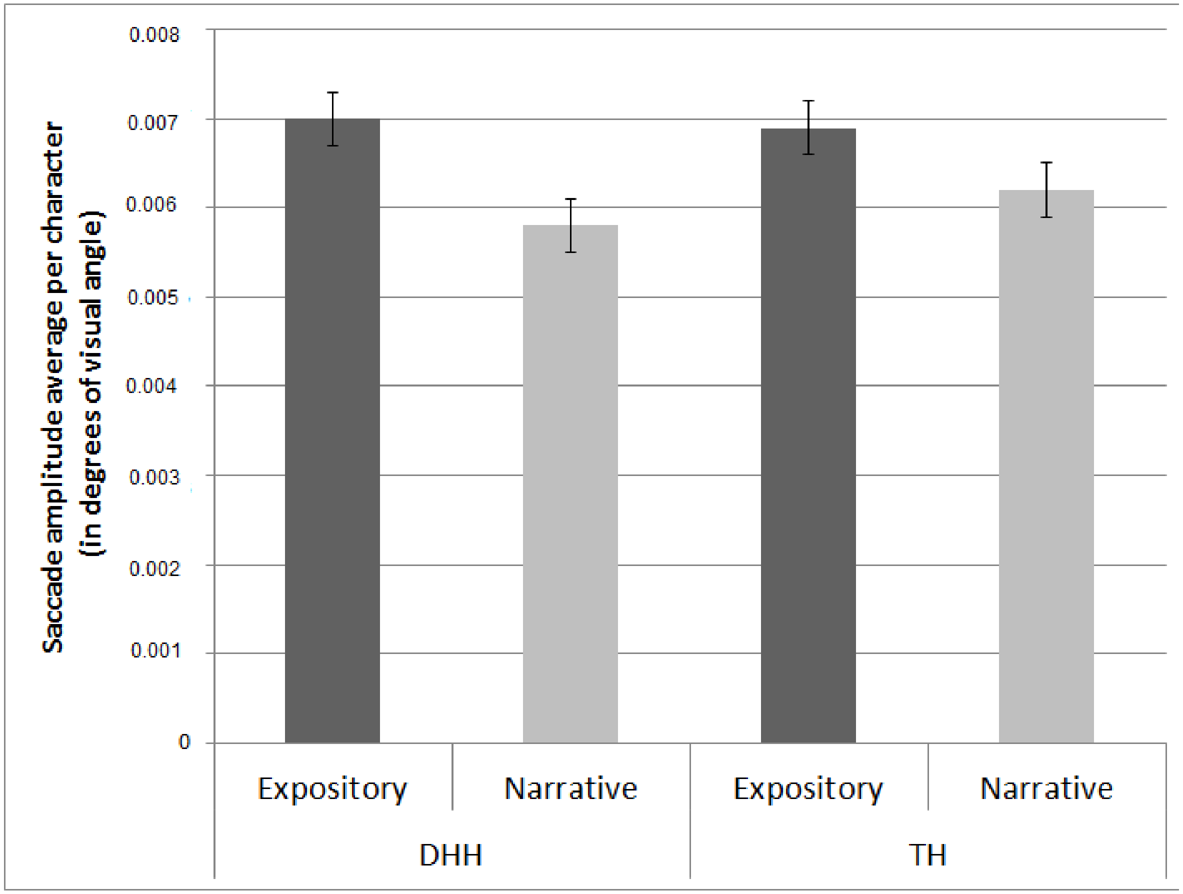
Means (M) and Standard Deviations (SDs) for each of the Eye-Movement Measures that were Obtained per the Global Text.

	Expository		**Narrative**	
	DHH (N=19) ***M (SD)***	**TH (N=19)** ***M (SD)***	**DHH (N=19)** ***M (SD)***	**TH (N=19)** ***M (SD)***
Percentage of correct answers	56.58 (24)	68.42 (25)	59.21 (32)	85.53 (15)
Eye-Movement measure	**DHH** ***M (SD)***	**TH** ***M (SD)***	**DHH** ***M (SD)***	**TH** ***M (SD)***
Dwell Time (ms)	36083 (15475)	32607 (12560)	36096 (16064)	30543 (9158)
Dwell Time per character (ms)	105.20 (8.26)	95.06 (8.26)	89.35 (8.26)	75.60 (8.26)
Average Fixation Duration per word (ms)	278.57 (116.94)	286.66 (123.1)	271.14 (118.65)	275.16 (120.04)
Average Fixation Duration per character (ms)	67.28 (3.88)	70.73 (3.87)	71.96 (3.80)	72.02 (3.79)
Regressive Fixations (per)	21.28 (6.63)	19.55 (6.92)	18.28 (7.08)	17.80 (5.96)
Progressive Fixations (per)	78.72 (6.63)	80.45 (6.92)	81.73 (7.08)	82.20 (5.96)
Saccade Amplitude Average (Visual angle per character)	0.007 (0.0003)	0.0069 (0.0003)	0.0058 (0.0003)	0.0062 (0.0003)
Saccade Amplitude Average (number of characters per saccade)	6.18])	5.87	5.43	6.05

Note. In order to facilitate interpretation, we report both, data averaged and non-averaged per character and untransformed means (M) and standard errors (SE) although linear mixed models were computed with transformed data averaged per character (except in the case of percentage of progressive and regressive fixations). Details and results of the linear mixed model computed with untransformed data are provided in "Supplementary data".

Figure 1

Saccade Amplitude Average per character as a function of Text Genre and Hearing Status



Note. Saccade amplitude average expressed in degrees of visual angle not averaged per character