

Oral and Written Discourse Skills in Deaf and Hard of Hearing Children

The Role of Reading and Verbal Working Memory

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This study examined the discourse skills of deaf and hard of hearing (DHH) children by comparing their oral and written narratives produced for the wordless picture book, *Frog, Where Are You?* (Mayer, 1969), with those of school-age-matched hearing peers. The written stories produced by 42 Italian 7- to 15-year-old children with moderate to profound hearing loss were compared with those of 48 school-age-matched hearing controls (age range = 7-13 years). The amount of linguistic information produced, measured as the number of words and clauses produced, the ability to generate a narrative structure, and coherence relations between the clauses of the story were investigated. The contribution of age, reading skills, and verbal working memory (measured as forward and backward digit span scores) were investigated relative to DHH children's ability to produce connected discourse in oral and written modalities. Deaf and hard of hearing children showed poorer discourse skills in oral and written narration; however, their disadvantage appeared to be greater in the written modality. Reading comprehension skills accounted for significant variance in DHH children's ability to generate narrative discourse. Yet, forward digit span scores, representing verbal rehearsal skills, contributed uniquely to the coherence of their narratives once age and reading comprehension were controlled. The contribution was greater in the written modality, suggesting that DHH children's greater disadvantage in this modality was related to the greater cognitive costs of the writing task. **Key words:** *deaf children, discourse skills, narrative, reading skills, verbal rehearsal, verbal working memory*

DISCOURSE ABILITIES may be defined as an individual's abilities to organize communicative content in a specific genre,

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such as narrative or expository discourse. It is widely acknowledged that deaf and hard of hearing students have significant problems in oral and written discourse at a microstructural level, including difficulty in spelling and in the construction of grammatically correct and complex sentences (Albertini, Stinson, & Zangana, 2014; Antia, Reed, & Kreimeyer, 2005; Arfé, Nicolini, & Pozzebon, 2014; Geers & Hayes, 2011; McAfee, Kelly, & Samar, 1990; Wolbers, 2008). However, greater uncertainty surrounds their discourse abilities. For example, questions include whether discourse

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skills are compromised in deaf children, and if so, which aspects of discourse ability are more affected by hearing loss (e.g., Arfé & Boscolo, 2006; Crosson & Geers, 2001; Marschark, Mouradian, & Halas, 1994).

In this article, I examine deaf and hard of hearing (DHH, henceforth) children's ability to generate oral and written narrative discourse. The language experience of DHH children can be very diverse, ranging from the sole use of oral language, the primary use of sign language, to bilingual or bimodal communication (i.e., the use of both oral and sign languages, or the use of oral language supported by signs; Spencer & Marschark, 2010). However, the ability to produce oral and written languages can be considered a crucial achievement for many DHH children (Geers, Nicholas, & Sedey, 2003; Moeller, Tomblin, Yoshinaga-Itano, McDonald Connor, & Jerger, 2007; Reuterskiold, Ibertsson, & Sahlen, 2010; Worsfold, Mahon, Yuen, & Kennedy, 2010). Researchers have systematically studied the vocabulary, morphological, and syntactic skills of DHH children (both oral and written; see Moeller et al., 2007; Spencer & Marschark, 2010). Yet, studies on their discourse abilities are rare (Moeller et al., 2007). It is important to understand how these children master not only linguistic skills at the word and sentence levels but also discourse skills, in oral and written language (see Arfé et al., 2014; Boons et al., 2013; Tur-Kaspa & Dromi, 2001).

Storytelling is one of the most widely investigated discourse skills in typically developing children (Ravid & Berman, 2006; Trabasso & Nickels, 1992). Yet, to date, only a few studies have focused specifically on narrative discourse abilities in DHH children (e.g., Crosson & Geers, 2001; Herman, Rowley, Mason, & Morgan, 2014; Reuterskiold et al., 2010). Storytelling involves—but is not limited to—linguistic abilities at the word and sentence levels such as vocabulary and syntactic skills. Important aspects of narrative discourse also depend on related cognitive-linguistic abilities, such as the ability to use world knowledge, to generate mental representations (e.g., story schemata),

and to convey coherent relations among the elements of the story; these, in turn, require a sense of audience, memory, and planning skills (Arfé & Boscolo, 2006; Carretti, Re, & Arfé, 2013; van den Broek, Linzie, Fletcher, & Marsolek, 2000). These macrostructure aspects have been found to be independent of the microstructural quality of DHH students' narratives at the word and sentence levels (Antia et al., 2005) and only partially related to their linguistic (i.e., grammatical) skills (Arfé & Boscolo, 2006).

The study presented in this article was designed to add to the current knowledge of DHH children's discourse skills by examining the oral and written narratives they constructed using the wordless picture storybook, *Frog, Where Are You?* (Mayer, 1969). This included analysis of the factors that contribute to explaining the semantic structure and local coherence of their narratives. Three factors that play a role in the development of narrative skills in hearing children were considered: age, reading skills, and verbal working memory (Carretti et al., 2013; Duinmeijer, de Jong, & Scheper, 2012; Trabasso & Nickels, 1992).

The importance of examining DHH children's narrative abilities in oral and written discourse relates to the different skills that this analysis may reveal (see Asker-Arnason et al., 2012; McAfee et al., 1990). Oral and written modalities are forms of expression that differ both linguistically (Halliday, 1989; Ravid & Berman, 2006) and cognitively (Bereiter & Scardamalia, 1987; Ravid & Berman, 2006). Written language is typically a more precise form of expression than oral language (Halliday, 1989), allowing revision and thus greater control of linguistic production than oral language (Ravid & Berman, 2006). However, the greater self-monitoring and transcription processes that are typical of writing entail additional cognitive costs compared with oral production, increasing the demands of generating discourse, particularly in developing writers (Berninger et al., 1992; Berninger & Swanson, 1994; Ravid & Berman, 2006). These oral and

written modality differences might impact children's ability to produce discourse structures and coherence. The few studies that have examined DHH students' storytelling in both oral and written modalities suggest that the written modality is more difficult or demanding for them than the oral modality (Arfé, Rossi, & Sicoli, 2015; Kelly & Whitehead, 1983; McAfee et al., 1990). However, there are also contrasting findings, which indicate that DHH students may produce more complete stories, measured as more story-grammar elements, in written modality than in oral modality (Asker-Arnason et al., 2012). Hence, further research on this topic is needed.

DEAF AND HARD OF HEARING CHILDREN'S ABILITY TO GENERATE NARRATIVE STRUCTURES

Various procedures, including watching and retelling movies, responding to verbal prompts or single-picture prompts, and telling stories to accompany wordless picture sequences or picture storybooks, have been used to elicit oral and written storytelling in hearing and DHH children. This latter method has been particularly widespread in research with DHH students (Arfé & Boscolo, 2006; Boons et al., 2013; Crosson & Geers, 2001; Tur-Kaspa & Dromi, 2001). Not only do picture stories facilitate the child in the storytelling task by providing content for the narration, but they also allow for more precise comparisons of children's productions because all children have to tell a story based on the same sequence of events (Duinmeijer et al., 2012).

In hearing children, the narration of picture stories has been found to evolve from descriptions of isolated states or actions, toward an organization in episodes, which are related to each other in hierarchical goals and plans of action within a hierarchical plot (Trabasso & Nickels, 1992; Trabasso, Stein, Rodkin, Park Munger, & Baughn, 1992). In mature stories, the goal plan hierarchy is characterized at least by a setting, or opening, which establishes a protagonist's state or

possession of a valued object, an initiating event, or the happenings that motivate the protagonists' goal(s). This is followed by two or more episodes, which are logically related to the protagonist's initial goal (e.g., to reobtain the lost object), and followed by a conclusion, which closes the goal plan sequence (Trabasso & Nickels, 1992; Trabasso et al., 1992). The protagonist's goals and the outcomes of his or her actions can be explicit or implicit, but, in a good story, they must be easily inferable by the listener or reader.

The ability to generate meaning relations, such as temporal, causal, or referential links between two discourse segments (e.g., clauses), is a crucial skill in discourse. It is necessary for establishing coherence (Sanders & Noordman, 2000) and is related to reading abilities among hearing children (Cain, 2003). Hearing children typically develop this discourse skill during their school years (Cain, 2003; Ravid & Berman, 2006; Trabasso & Nickels, 1992). Coherence relations are conceptual and can be, but are not necessarily, made explicit through linguistic markers such as pronouns or conjunctions (Sanders & Noordman, 2000). Hence, the concept of coherence relations can partially overlap with—but is not the same as—cohesion, that is, the linguistic connectedness of discourse. In this article, the expression *coherence relations* (Sanders & Noordman, 2000) is preferred to cohesion, to refer to meaning relations that encompass both linguistically explicit and implicit meaning relations.

Prior studies that have examined DHH children's discourse skills have produced mixed results. Some findings indicate that DHH students have significant trouble following the rules of narrative organization in writing (Banks, Gray, & Fyfe, 1990; Yoshinaga-Itano & Downey, 1992, 1996) or generating written stories that have the typical hierarchical structure of narratives (Arfé & Boscolo, 2006). Other studies indicate that the oral and written stories produced by DHH students are less focused on the relevant story-grammar elements, are more incomplete (i.e., contain

fewer setting, initiating event, and solution elements), and are less cohesive at the local level than those of their hearing peers (Arfé et al., 2014; Boons et al., 2013; Crosson & Geers, 2001).

Contrasting data, however, suggest that DHH students are able to generate written stories that are comparable with those of their hearing peers in terms of their organization in internally coherent episodes (Arfé & Boscolo, 2006; Marschark et al., 1994). Some research also indicates that DHH students can use coherence relations and connectives in their narratives to relate information at the local level (Arfé & Boscolo, 2006; Reuterskiold et al., 2010).

Finally, some studies show that DHH students typically include in their stories as much information, measured in T-units* or story details, as their hearing peers (Arfé & Boscolo, 2006; Boons et al., 2013; Spencer, Barker, & Tomblin, 2003). This provides evidence that their stories appear poorer and more incomplete at the discourse level not because they include less information in their productions, but because the information they include is not always relevant. Moreover, DHH children struggle to generate linguistic links between words (e.g., Arfé et al., 2014; Spencer et al., 2003); thus, it is possible that the more words and sentences they generate, the more difficult it is for them to connect this information in a coherent semantic structure.

FACTORS ASSOCIATED WITH DHH CHILDREN'S DISCOURSE SKILLS

In hearing children, age is the first factor explaining the development of narrative skills. Indeed, significant changes occur with age in narrative ability, associated with the child's linguistic, cognitive, and literacy development (Ravid & Berman, 2006; Trabasso

& Nickels, 1992). Yet, things can be different for DHH children, whose linguistic and literacy maturity does not necessarily correspond to their chronological age (Arfé & Boscolo, 2006; Arfé & Perondi, 2008; Wolbers, Dostal, & Bowers, 2012).

Reading is another important factor for the development of narrative skills. Hearing and DHH children experience narrative discourse through both oral (or sign) language and reading (Arfé & Boscolo, 2006; Carretti et al., 2013; Crosson & Geers, 2001; Pakulski & Kaderavek, 2012). Reading, however, holds a special importance for DHH children because their auditory access to speech is often limited and they do not always have the opportunity for sufficient experience of narrative discourse in sign language (Mayer, 1999; Steinberg, 2000). Not surprisingly, narrative skills have been found to be significantly correlated to DHH children's reading comprehension abilities (Crosson & Geers, 2001; Yoshinaga-Itano & Snyder, 1985). The association between story reading and storytelling also can be explained by the components the two activities have in common. For example, both require the ability to make use of discourse structures and to establish coherence relations between the generated and read information (Cain, 2003; Carretti et al., 2013; Yoshinaga-Itano & Downey, 1992).

A further factor that can contribute to explaining variance in oral and written storytelling is verbal working memory (Alamargot, Lambert, Thebault, & Dansac, 2007; Arfé et al., 2014; Arfé et al., 2015). Planning the structure of a story and generating the necessary meaning relations between the utterances and sentences are processes that may challenge the child's memory system (Dodwell & Bavin, 2008; Duinmeijer et al., 2012). Surprisingly, the role of working memory in the oral and written storytelling of children with hearing loss has been neglected in research.

Prominent models of verbal working memory characterize it as having two important functions in discourse production. One of its components, the phonological loop, sustains the active maintenance of information that

*T-units are syntactic and content unit corresponding to a main clause and all subordinate clauses linked to it (Hunt, 1965).

must be produced via rehearsal or “refreshing” mechanisms (see Baddeley, 2010). A second component, the central executive, oversees the memory processes to maintain the relevant information (e.g., words, concepts) active in memory while performing other tasks (e.g., planning sentences in discourse or generating new ideas; Acheson & MacDonald, 2009; Baddeley, 2010). A simple measure of verbal working memory, such as digit span, can be used to assess both these functions (Gathercole, Pickering, Ambridge, & Wearing, 2004). Forward digit span taps the ability to use verbal rehearsal mechanisms. Backward digit span requires both maintenance and transformation of the input, thus it implies executive control mechanisms (Gathercole et al., 2004; Harris et al., 2013).

In hearing children, verbal rehearsal skills appear to contribute more to the semantic organization of oral stories than executive working memory skills (Dodwell & Bavin, 2008; Duinmeijer et al., 2012). On the contrary, the executive component of working memory seems to have greater impact on the macrostructure quality of written narration (Swanson & Berninger, 1994, 1996). This may be because writing involves greater executive control over linguistic production than oral language (Hooper, Swartz, Wakely, de Kruif, & Montgomery, 2002).

To date, few studies have examined the contribution of verbal working memory to DHH children’s narrative abilities (Arfé et al., 2014; Arfé et al., 2015). However, the verbal rehearsal mechanisms measured by forward digit span, which appear to be significantly compromised in deaf children (Pisoni & Cleary, 2003; Pisoni, Kronenberg, Roman, & Geers, 2011), seem to be related to the microstructural quality of their written stories (Arfé et al., 2014). The executive component of their verbal working memory, which in some studies seems comparatively better preserved (e.g., Harris et al., 2011; Pisoni & Cleary, 2003), apparently contributes to the macrostructure of their oral and written narration (Arfé et al., 2015).

THE STUDY

The goal of this study was to explore DHH children’s discourse skills by examining their ability to generate stories in oral and written modalities using a wordless picture storybook, *Frog, Where Are You?* The study considered three factors that can contribute to explaining the semantic structure and local coherence of DHH children’s narratives: age, reading skills, and verbal working memory. Discourse measures included children’s *productivity* (i.e., the number of words and clauses produced), use of *story structure* (i.e., story-grammar elements incorporated), and ability to generate *coherence* (i.e., semantic relations between the clauses). Children’s reading comprehension scores, as well digit span forward and digit span backward measures, were used to assess their reading and verbal working memory skills.

The participants in the study were children with moderate to profound hearing loss, compensated by hearing aids. Despite the significant growth of cochlear implantation in the last 20 years, DHH children without a cochlear implant continue to represent a significant part of the DHH pediatric population (see Moeller et al., 2007; Worsfold et al., 2010). The written and oral stories produced by 42 Italian children, aged 7–15 years, with moderate to profound hearing loss, were compared with written and oral stories produced by 48 school-age-matched hearing controls (age range = 7–13 years).

The study was explorative. Yet, it was hypothesized that writing would present extra demands on the DHH children’s working memory compared with oral storytelling (see Arfé et al., 2015; McAfee et al., 1990). Consequently, a greater disadvantage was expected in the written modality by DHH children than by the hearing controls.

Another hypothesis based on prior research was that the generation of story structure (i.e., global story organization) for DHH children would be compromised more than the generation of local coherence relations between the information units of the story (e.g., Arfé &

Boscolo, 2006; Boons et al., 2013; Reuterskiold et al., 2010; Yoshinaga-Itano & Downey, 1992). I wanted to test this hypothesis and verify how these two discourse skills are related to children's age, reading comprehension skills, and verbal working memory. Because managing a greater amount of words and clauses may increase the cognitive demands of storytelling in DHH children, I further expected productivity in words and clauses to be related inversely to the ability to generate discourse structures and coherence relations in discourse.

METHODS

Participants

One hundred four Italian children were initially recruited for the study. The sample comprised 56 DHH children aged 6–15 years (mean age = 11.00 years, $SD = 2.44$; 23 girls) with bilateral and prelingual moderate to profound hearing loss, and a control group of 48 hearing children, aged 7–13 years, matched to the DHH participants for grade level (mean age = 10.52 years, $SD = 1.98$; 20 girls). Data were gathered between 2004 and 2005, with a few additional cases added in 2012. Deaf and hard of hearing children were recruited through special schools for the deaf and speech rehabilitation units. Data on the child's hearing loss, first language, rehabilitation method, and language environment were collected through a questionnaire, which was filled in by parents, with the support of the language pathologists who followed the child. Only DHH children who were reported to use oral language as their primary communication mode or in addition to sign language were recruited for the study.

All DHH children were reported by their parents and/or speech pathologist to be within the normal range at standardized tests of nonverbal intelligence. However, the children's nonverbal skills also were examined by a visual-motor integration (VMI) task (Beery, 1997). The VMI test requires children to copy a sequence of geometric forms of increasing complexity. The VMI scores are reported to

correlate significantly with nonverbal intelligence, $r = .66$, and scholastic performance, $r = .58$ (Beery, 1997). Like IQ, VMI weighted scores have a mean of 100 ($SD = 15$). A cutoff of 80 was used to exclude cases of cognitive impairment (see also Boons et al., 2013). Two of the 56 DHH participants originally selected scored less than 80 on the VMI task. Their data were thus excluded from subsequent analyses. Data for 12 DHH children who did not produce intelligible oral stories were further excluded from the analysis.

With the exclusion of these 14 children, the final sample of the study consisted of 42 DHH children (16 girls), with a mean age of 10.88 years ($SD = 2.37$; range = 7–15 years) and mean weighted VMI scores of 96 ($SD = 12.5$). Although the DHH children were on average older than their hearing peers, the two groups did not differ significantly for age, $F(1, 88) = 0.62$, $p = ns$. The participants' characteristics are presented in Table 1.

Of the DHH participants, 5 had moderate hearing loss (with a hearing threshold ≥ 40 dB), 7 had a moderate-to-severe or severe hearing loss (hearing threshold ≥ 60 dB), and 27 children had profound hearing loss (hearing threshold ≥ 90 dB). Information on the degree of hearing loss and language experience of three children was missing. At the time of the study, they attended a school where bimodal communication was used and followed speech therapy in the school.

Seventeen children were orally educated and used only oral language to communicate at home and at school. Sixteen children, who were orally educated, also were exposed to bimodal communication at school, the majority from elementary school. Six children were bilingual (oral/sign language users), that is, native signers who were also orally educated (see Table 1).

Procedure

Each child performed a standardized reading comprehension task (Cornoldi & Colpo 1998), the Wechsler Intelligence Scale for Children–Fourth Edition (WISC-IV) forward digit span and backward digit span task

Table 1. Demographics and descriptive statistics for DHH children and hearing children: Mean age, reading scores, forward digit scores, and backward digit scores

	DHH (<i>n</i> = 42)	Hearing (<i>n</i> = 48)
Girls, <i>n</i> (%)	16 (38)	20 (42)
Age, mean (<i>SD</i>)	10.88 (2.37)	10.52 (1.98)
Degree of hearing loss		—
Moderate, <i>n</i> (%)	5 (12)	
Moderate-to-severe, <i>n</i> (%)	7 (17)	
Profound, <i>n</i> (%)	27 (64)	
No data, <i>n</i> (%)	3 (7)	
Communication mode ^a		—
Oral, <i>n</i> (%)	17 (40)	
Oral/bimodal, <i>n</i> (%)	16 (38)	
Bilingual, <i>n</i> (%)	6 (14)	
NA, <i>n</i> (%)	3 (7)	
Reading raw scores, mean (<i>SD</i>)	6.31 (2.20)	9.17 (.91)
Forward digit scores, mean (<i>SD</i>)	4.0 (1.52)	6.38 (1.75)
Backward digit scores, mean (<i>SD</i>)	3.59 (1.60)	5.08 (1.64)

Note. DHH = deaf and hard of hearing; NA = not available.

^aIt was considered the first language of the child and the main mode of communication in family and at school.

(Wechsler, 2003), as well as a storytelling task in two modalities: oral and written.

Reading comprehension task

A reading comprehension task drawn from the Italian standardized battery for the assessment of reading decoding and reading comprehension (Cornoldi & Colpo, 1998) was administered to all children. The battery comprises a set of narrative texts, each appropriate for a different grade level, from Grades 1 to 8. The battery is the most widely used test in Italy for reading assessment, and it has proved to be sensitive to individual differences in reading ability in young Italian readers (Carretti et al., 2013; Desimoni, Scalis, & Orsolini, 2012). After reading the text, the child answers a set of multiple-choice questions about the story. To prevent floor effects in DHH children's performances, the intermediate third-grade test was selected for participants aged 8–15 years (Grade 3 onward) and the final first-grade test was administered to 7-year-olds (second graders). The choice was based on the last assessment of the children's reading skills and on esti-

mations of their reading levels provided by teachers and speech-language pathologists. Both tests comprised 10 multiple-choice questions. Thus, scores could range from 0 (no correct answers) to 10 (all answers correct).

Forward digit span

The task consists of repeating sequences of digits of increasing length in the same order as they are produced by the examiner. In this study, an adaptation of the WISC-IV, forward digit task (Wechsler, 2003, Italian standardization by Orsini, Pezzuti, & Picone, 2012), was used (Colombo, Arfé, & Bronte, 2012) to minimize problems due to DHH participants' imperfect access to the oral input. The task was administered bimodally, where the examiner produced the conventional signs of the digits while also speaking them. The child was asked to repeat the digits in the same order as the examiner produced them (see also, Arfé et al., 2014; Colombo et al., 2012). A score of 1 was given for the production of the digit orally or bimodally (orally plus signing), and no points were given if the digit was only produced by signing. The total score was considered

a measure of the child's verbal rehearsal skills (Orsini et al., 2012).

Backward digit span

The procedure was similar, except that the child was asked to repeat the sequence of digits backwards, that is, in reverse order. This has been considered to be a measure of the executive component of verbal working memory (Gathercole et al., 2004; Harris et al., 2013).

Oral and written storytelling

Each participant was met individually and was shown the wordless picture book, *Frog, Where Are You?* (Mayer, 1969), consisting of 24 wordless pages of pictures that tell the story of a boy and his dog in search of their lost pet frog. The child was asked to tell the story first orally and, subsequently, to write it on a sheet of lined paper, at the top of which the title *Frog, Where Are You?* was printed. Before starting to tell the story, the child was encouraged to look carefully at the pictures to see first how the story unfolded. To limit the use of pointing and deictic reference to the pictures, the child was told that the story would be video-recorded and watched by a friend of the experimenter, who did not know *Frog, Where Are You?* After having recounted the story aloud, the child was invited to write the story and was reminded to be as clear and complete as possible. Children were given the picture book and were told they could use it in retelling the story orally and in writing. They were also free to revise their written stories, although no specific instruction to revise was given. No time limits were given. The oral stories were video-recorded and subsequently transcribed by a trained speech therapist. Nine oral stories randomly chosen from the DHH sample were independently transcribed by the author. Inter-rater word-by-word transcription agreement was 97%.

Scoring

Oral and written stories were scored for *productivity* and *discourse structure*.

Productivity

The number of words and clauses produced in the oral and written stories was assessed as the *total number of words (TNW)* and *total number of clauses/or ideas (TNC/I)*. The TNW measure was a count of the number of intelligible words spoken or written by the student. It is considered an index of the linguistic productivity in oral and written modalities. The TNC/I measure was a count of clauses produced by the student. This was considered a measure of the number of information units or ideas produced in the narration. Although several studies have used T-units as a measure of the number of ideas produced (Arfé & Boscolo, 2006; Crosson & Geers, 2001), Arfé and Perondi (2008) found that in Italian deaf students, a T-unit corresponded typically to one clause.* Therefore, the number of clauses produced was a good approximation of the number of ideas generated. All recognizable finite and infinitive clauses, correct and incorrect, were counted to yield the TNC/I.

Discourse structure

Discourse structure was assessed by means of a *story structure* score and a *coherence relations* score. The story structure score was defined on the basis of findings of Trabasso and collaborators (Trabasso & Nickels, 1992; Trabasso et al., 1992), who identified five minimal components for a good *Frog, Where Are You?* story: the setting (i.e., the boy has a pet frog), the initial event (i.e., the frog is missing), which motivates the main goal of the protagonist(s) (i.e., to find the frog), at least two episodes that logically and hierarchically relate to the protagonist's goal and in which the protagonist performs actions to resolve the problem (i.e., search for the frog in the room, search outside, or search for the frog everywhere), and a solution or final outcome

*The authors calculated the mean number of clauses per T-units and found that it corresponded to 1.2 clauses per each T-unit.

(i.e., the frog is finally found). A score from 0 to 5 was assigned to DHH children's stories by counting the number of these story-grammar elements included in the narration. The score was given only if the elements were presented in the correct logical or hierarchical order (e.g., if the setting was opening the story).

The coherence relations score is an adaptation of the Scinto index (Scinto, 1984). This is calculated as the ratio of recognizable coherence relations, or semantic links, between clauses over the number of clauses in the story. The more disruptions the reader perceives in the story flow, the less the story is perceived as coherent. Thus, relations between adjacent clauses were scored "1" when perceived as coherent by the reader and "0" if the semantic link between the information contained in the two clauses was lacking, unclear, or ambiguous. Clear semantic links could be explicit and expressed by the appropriate use of a conjunction (e.g., *but*, *because*, *so*, *then*), adverbial phrase (e.g., *in the night*, *next morning*), pronoun (e.g., *he*, *she*, *they*), noun (e.g., *the boy*, *Mark*, *the dog*) such as in "The boy and the dog went in search of the frog. They searched first." Semantic links also could be implicit, but logically clear to the reader, such as in "(1) The boy and the dog wake up. (2) The frog is no longer there. (3) The boy looks everywhere in the room," where the causal relation between (2) and (3) is inferred by the reader. Interrater reliability was computed for all the stories by asking a research assistant and a graduate student to each score 50% of the stories that had been scored by the author. The two independent raters were blind to the groups of the DHH and hearing students: Pearson correlations ranged from .98 for the number of words to .84 for story coherence.

RESULTS

Analyses of variance with age as a covariate were run first to explore differences between the reading comprehension and working memory skills of the DHH and hearing

participants. Table 1 reports means and standard deviations for DHH and hearing children's reading, digit forward and digit backward scores.

The hearing children showed significantly higher level of reading skills: $F(1, 87) = 65.92$, $p < .001$, $\eta^2_p = 0.43$. On the reading comprehension test, seven DHH children aged from 8 to 10 years and 12 children aged from 10 to 15 years performed below the norms for Grade 3. The younger, 7-year-old, DHH children ($n = 3$) performed at the expected reading level for Grade 1. The hearing children also showed significantly greater forward digit span scores and backward digit span scores than the DHH children. The results for forward digit span scores were $F(1, 87) = 48.97$, $p < .001$, $\eta^2_p = 0.36$; results for the backward digit span scores were $F(1, 87) = 23.28$, $p < .001$, $\eta^2_p = 0.21$ (see also Table 1). Eta squares represent the dimension of the effect. The largest effect size was for reading skills. As for working memory, the dimension of the effect was greater for forward digit span than for backward digit span scores, indicating a larger gap between the groups in verbal rehearsal than executive working memory skills. This finding is consistent with prior research (Pisoni & Cleary, 2003).

Between-group differences in oral and written storytelling were analyzed by two multivariate analyses of variance, with age as covariate. The two productivity scores, *TNW* and *TNC/I*, and the two discourse scores, *story structure* and *coherence relations*, were dependent variables. Results of these analyses are summarized in Table 2.

Oral storytelling

Productivity

The hearing and DHH children produced oral stories of equivalent length in the number of words, $F(1, 87) = 0.05$, $p = ns$. However, the DHH children produced more clauses than the hearing children in their oral stories, $F(1, 87) = 4.54$, $p < .05$, $\eta^2_p = 0.05$.

Table 2. Differences between hearing children and DHH children in oral and written discourse skills: TNW, TNC/I, story structure score, and coherence relations score (standard deviations in parenthesis)

	Oral Storytelling		Written Storytelling		<i>p</i>
	DHH (<i>n</i> = 42)	Hearing (<i>n</i> = 48)	DHH (<i>n</i> = 42)	Hearing (<i>n</i> = 48)	
TNW	181.7 (87.32)	182.9 (74.98)	111.2 (58.69)	140.2 (60.94)	.005
TNC/I	38.29 (15.72)	31.31 (13.37)	24.17 (11.29)	24.65 (10.52)	<i>ns</i>
Story Structure	4.07 (2.35)	4.6 (1.12)	3.8 (1.64)	4.8 (1.34)	<.005
Coherence Relations	0.43 (0.30)	0.83 (0.08)	0.40 (0.31)	0.78 (0.14)	<.001

Note. TNC/I = total number of clauses/or ideas; TNW = total number of words.

Discourse structure

In oral narrations, the *story structure* of the hearing and DHH children’s narratives did not differ, $F(1, 87) = 2.19, p = ns$. However, the hearing children produced proportionally more *coherence relations* than the DHH group, $F(1, 87) = 77.61, p < .001, \eta^2_p = 0.47$.

Written storytelling

Productivity

In written modality, the hearing children produced significantly more words than the DHH children, $F(1, 87) = 8.29, p = .005, \eta^2_p = 0.09$. However, the number of clauses produced by the two groups was equivalent, $F(1, 87) = 0.25, p = ns$.

Discourse structure

The written stories produced by the hearing group were more complete in terms of *story structure*, $F(1, 87) = 9.28, p < .005, \eta^2_p = 0.10$, and also were coded as having more *coherence relations* than those of their DHH peers, $F(1, 87) = 60.24, p < .001, \eta^2_p = 0.41$.

The contribution of age, reading skills, and forward and backward digit span scores to DHH children’s discourse skills in oral and written modalities

Partial correlations controlling for age were run to explore the relationship between hearing and DHH children’s reading comprehension skills, forward and backward digit span scores, and measures of oral and written story production. To control for Type 1 errors, Bonferroni corrections were applied, and the level of significance was adjusted to .007. Multiple hierarchical regressions were run, subsequently, to explore the unique contribution of age, reading skills, and forward digit span and backward digit span scores to oral and written storytelling.

Hearing children produced structurally complete stories in both oral and written modalities and were able to produce coherence relations between the clauses of the story. Therefore, their performance showed ceiling effects and little variance at the

discourse level. For this group, the correlational analyses revealed only a significant correlation between reading comprehension skills and story structure in the oral modality, $r(48) = .47, p < .001$, and between reading comprehension abilities and coherence relations in the written modality, $r(48) = .47, p < .001$. No correlations between hearing children's narrative skills and their digit span scores were found. Multiple regression analyses were thus performed only for the DHH group. Table 3 reports the correlations for the DHH group.

In oral storytelling, DHH children's reading skills correlated marginally ($p = .008$) with their ability to generate the story structure and significantly with coherence relations. Forward and backward digit span scores were marginally associated with coherence relations. In written storytelling, after Bonferroni corrections, only the association between reading scores and coherence relations was significant. Forward and backward digit span scores were significantly associated with coherence relations. Productivity measures (number of words and clauses) correlated positively with story structure and coherence relations in oral discourse and with story structure scores in written discourse (see Table 3).

Hierarchical regression analyses were performed to explore the contribution of age,

reading skills, and verbal working memory to the DHH children's ability to generate story structure and coherence relations. Separate hierarchical regressions were run for oral and written story production. The models are summarized in Table 4.

Variance due to age was controlled first, by entering age at Step 1 of the regressions. As the literature reports a significant association between reading and narrative skills in deaf children (Crosson & Geers, 2001), reading comprehension scores were entered at Step 2. The unique contribution of forward digit span and backward digit span scores to oral and written storytelling was then analyzed. Forward digit span scores were entered at Step 3 as a measure of verbal rehearsal skills, and backward digit span scores were entered last to test the unique contribution of the executive component of verbal working memory, after controlling for age, reading skills, and verbal rehearsal. Discourse measures (*story structure* and *coherence relations* scores) of the oral and written stories were dependent variables. Bonferroni corrections were applied, with the level of significance adjusted to .01.

Oral storytelling

Reading scores at Step 2 accounted for 17% of variance in *story structure*. The full model,

Table 3. Correlations between DHH children's reading scores, digit forward and digit backward scores, and productivity (TNW and TNC/I), story structure, and coherence relations measures

	1	2	3	4	5	6	7
1. Reading_compreh	-	.25	.35	.34	.20	.41*	.51**
2. Digit forward	.25	-	.41	.26	-.00	.23	.41*
3. Digit backward	.35	.41	-	.20	.05	.16	.41*
4. TNW	.28	.28	.22	-	.89**	.48*	.61**
5. TNC/I	.18	.13	.15	.81**	-	.43*	.35
6. Story structure	.30	.30	.29	.47*	.48*	-	.16
7. Coherence relations	.58**	.58**	.43*	.41*	.27	.48*	-

Note. Correlations for oral storytelling above the diagonal, and for written storytelling below the diagonal ($n = 42$; age partialled out). DHH = deaf and hard of hearing; Reading_compreh. = reading comprehension; TNW = total number of words; TNC/I = total number of clauses/or ideas. Adjusted level of significance after Bonferroni corrections is .007. * $p = .008$. ** $p \leq .005$. *** $p \leq .001$.

Table 4. DHH children: The contribution of age, reading scores, forward digit and backward span scores to oral and written discourse skills

Regression Step		Oral		Written	
		ΔR^2	β	ΔR^2	β
Story structure					
1	Age	.01	.11	.01	-.08
2	Reading_compreh	.17**	.42**	.09 [#]	.29 [#]
3	FDigit span	.02	.14	.06	.24
4	BDigit span	.00	-.04	.01	.15
Total R^2		.19		.17	
Coherence relations					
1	Age	.01	-.09	.00	.06
2	Reading_compreh	.26***	.52***	.34***	.59***
3	FDigit span	.09*	.30*	.21***	.47***
4	BDigit span	.02	.18	.01	.09
Total R^2		.38**		.55***	

Note. DHH = deaf and hard of hearing; Reading_compreh = reading comprehension scores; FDigit span = forward digit span scores; BDigit span = backward digit span scores
[#] $p \leq .06$. * $p \leq .05$. ** $p \leq .01$. *** $p \leq .005$.

however, was not significant, $F(4, 36) = 2.24$, $p = .09$. Reading skills also contributed to explaining 26% of the variance in *coherence relations*. Verbal rehearsal skills, measured as forward digit span, accounted for a further 9% of unique variance. However, after Bonferroni corrections, their contribution was not significant ($p < .05$). In this case, the full model was significant, $F(4,36) = 5.45$, $p < .005$.

Written storytelling

Reading scores, at Step 2, contributed marginally to explain 9% of variance in the written *story structure*. The full model was not significant, $F(4, 36) = 1.78$, $p = ns$. Reading skills explained 34% of variance in *coherence relations* scores; however, verbal rehearsal skills at Step 3 accounted for a further 21% of unique variance in written *coherence relations*. The full model was significant, $F(4, 36) = 11.09$, $p < .001$.

DISCUSSION

This study investigated DHH children’s discourse skills by examining their ability to gen-

erate stories from the wordless picture book, *Frog, Where Are You?* in both oral and written modalities. Two types of discourse skills have been considered in this study: (1) children’s ability to organize content in a narrative structure, and (2) their ability to generate coherence relations between the information produced at the local level.

In line with prior research (e.g., Crosson & Geers, 2001; Yoshinaga-Itano & Downey, 1992), it was hypothesized that the discourse skills of DHH children would be poorer than their hearing peers. The results of the study confirmed this expectation. However, contrary to the existing literature (Arfé & Boscolo, 2006; Reuterskiold et al., 2010) and the hypotheses of this study, DHH children’s performance appeared to be more compromised when local coherence scores were considered. Their ability to generate local *coherence relations* in the story was poor, both in oral narration and in written narration. In the oral stories, the proportion of *coherence relations* generated was .43 with a maximum of 1, whereas in the hearing controls it was .83. In the written stories, DHH children’s

coherence relations score was .40 compared with .78 in their controls.

The participants in this study had, on the one hand, a more severe hearing loss than the participants in Reuterskiold et al.'s (2010) study (with mild-to-moderate hearing loss), and on the other hand, they were younger than the students tested by Arfé and Boscolo (2006). In addition, Reuterskiold et al. (2010) only assessed the use of connectives in discourse. The analysis in this study was more comprehensive, including all kinds of coherence relations between clauses (e.g., connectives, anaphoras, and implicit links). These elements together can explain the difference between the present findings and prior research, which found that DHH children were able to produce local coherence relations in their oral and written stories.

In comparison, the DHH children structured their stories quite well at a global level. In oral narration, they tended to produce stories that contained the same number of core story elements as their controls. In the written narrations, they included fewer story elements than their controls. However, their mean *story structure* score was 3.8; that is, they omitted on average only one of the five core elements of the story. Often it was the setting.

A first possible interpretation of these findings is that the use of organized picture sequences may have facilitated the task of generating the elements of the plot—the setting, initial event, attempts, and outcome—which are represented, and ordered, in the picture sequence in the book (see also Arfé & Boscolo, 2006; Duinmeijer et al., 2012). However, the generation of local *coherence relations* between the information contained in the clauses was not facilitated, because this involved the child's linguistic skills to a greater extent. Examples were demands to use linguistic devices such as pronouns and connectives to build coherence across clauses (see also Arfé & Perondi, 2008; Crosson & Geers, 2001). Although this is possible, it must be noted that coherence

relations do not necessarily depend on the use of linguistic links (Arfé & Boscolo, 2006; Sanders & Noordman, 2000), and there are indeed studies showing that deaf children can generate good *coherence relations* at a local level in their stories (Arfé & Boscolo, 2006; Marschark et al., 1994). An example from the current study is as follows: *They hear noises behind a tree. The boy says "shhh" to the dog* (boy, profound hearing loss, 9 years). In this case, the coherence relation is implicit and must be inferred by the reader. Therefore, the greater difficulty in using cohesion devices cannot be the only explanation for these results. Other factors must then be considered.

Another possible explanation for these findings, compatible with the previous one, is the possible influence of DHH children's verbal working memory skills in storytelling. The ability of DHH children to generate coherence links between the clauses of a story may be limited because this cognitive operation draws on verbal memory resources that are most compromised in DHH children. Short-term temporary storage and verbal rehearsal may be crucial to maintaining in memory the information contained in two adjacent clauses for the time necessary to relate their meaning or compute linguistic relations (e.g., anaphors; Millogo, 2005). This is particularly critical for DHH children, whose rehearsal skills are poor (see Pisoni & Cleary, 2003; Pisoni et al., 2011). The results of the hierarchical regressions suggest this may be the case. Forward digit span scores of DHH children's accounted for 9% and 21% of unique variance in *coherence relations* in oral and written stories, respectively, once age and reading skills were controlled.

Verbal working memory appeared to be less involved in generating the story structure elements of the story. The picture sequence provided an external support for DHH children's memory in this task. By following the sequence of pictures, DHH children could receive support in generating and producing the elements of the story structure (the setting, initial event, attempts, and outcome)

without overloading their verbal working memory.

Although supported by the picture sequence, the DHH children probably also used their knowledge of story genre to structure their stories as the association between their story reading skills and story structure scores would suggest. Their reading abilities also were associated with their ability to generate coherence relations. Prior research already has demonstrated that intervention on story reading may positively affect DHH children's narrative skills (Pakulski & Kaderavek, 2012). This may happen not only because children experience the narrative genre and register through reading but also because learning to identify and establish coherence relations is an important component of both reading comprehension and storytelling abilities (Arfé & Boscolo, 2006; Cain, 2003; Sanders & Noordman, 2000).

The disadvantage faced by DHH children compared with their hearing peers was more evident when storytelling skills were assessed in written modality than in oral modality. In oral storytelling, the DHH and hearing groups differed only in their ability to generate *coherence relations*. In contrast, in written storytelling, differences between the two groups emerged for both *coherence relations* and *story structure*. This was consistent with the second hypothesis of the study that DHH children would have greater problems in written storytelling than their peers. The greater involvement of verbal rehearsal skills in written narration may contribute to explaining this result. Forward digit span scores indeed contributed to explaining more variance in DHH children's written narration than oral narration. Contrary to the existing literature on hearing children (Swanson & Berninger, 1996), however, in written narration, the contribution of the DHH children's executive working memory skills (i.e., backward digit span scores) was not significant (see Table 4). As argued by other authors (Gathercole et al., 2004; Harris et al., 2013), backward digit span is a simple working memory measure. It is possible that more complex verbal working mem-

ory measures (e.g., reading span) are necessary to tap DHH children's executive working memory skills (see Arfé et al., 2015).

Another result that merits a brief discussion is that forward digit span, representing verbal rehearsal skills, accounted for variance in DHH children's discourse abilities. This suggests that verbal rehearsal mechanisms in DHH children support not only vocabulary and grammatical skills (Harris et al., 2013; Pisoni & Cleary, 2003) but also higher level language processes, such as discourse production. As noted previously, inefficient verbal rehearsal might impact on DHH children's ability to generate coherence links between the clauses of a story. The implications of this finding for rehabilitation and educational intervention are discussed in the "Implications" section.

Contrary to the hypotheses, the amount of information produced in the stories, measured as words and clauses, was significantly correlated with DHH children's *story structure* and *coherence relations* scores. A possible interpretation of these findings is that those children who told longer stories also were those with better language skills, which, in turn, facilitated the task of generating good discourse structures.

Limitations

This study had some limitations that deserve mention. First, it compared only oral and written narratives. Twelve of the participants originally selected for the study could not produce intelligible oral stories. These students might have produced, however, intelligible and clear stories in sign language (see Herman et al., 2014). An interesting avenue for future studies could be to compare the cognitive costs of written narrations of DHH children who are orally educated with those of sign language users, as well as the cognitive costs of oral and signed narration.

A second limitation of this study is that only simple verbal working memory measures (i.e., forward and backward digit span) were used to assess DHH children's verbal working memory. Although forward and backward

digit span scores have been demonstrated to explain a wide range of language skills in DDH children (Arfé et al., 2014; Harris et al., 2013; Pisoni & Cleary, 2003), it is possible that more complex measures of verbal working memory would be necessary to tap the central executive working memory skills involved in discourse production. Executive skills have been found to be a crucial factor for the written production of hearing children (e.g., Hooper et al., 2002). To gain a more comprehensive understanding of DHH children's problems with oral and written discourse production, it is important to determine their role also in DHH children's oral and written discourse.

A last limitation could be the reading comprehension task used in this study. The results indicate that the Grade 3 reading test captured individual differences in DHH children's reading skills and DHH children's reading scores correlated with their narrative skills. However, this test was too simple to capture the variance in the hearing children's reading comprehension skills as well. The selection of tasks (and measures) that are equally sensitive to variance in both hearing and DHH children's literacy abilities is probably one of the main challenges in the research with DHH children.

Implications

Two results of this study may have significant implications for assessment and instruction of higher level language skills in DHH children. First, two discourse skills were assessed in this study—first, children's ability to generate a *story structure* and, second, their ability to link the information in their stories by *coherence relations*. Both discriminated between hearing and DHH children. However, the results suggest that the evaluation of DHH children's discourse abilities may vary greatly according to which measure we consider. *Story structure* scores reveal a relatively good performance in narrative discourse compared with hearing peers, at least in the oral condition. In contrast, *coherence relations* scores suggest a signif-

icant difficulty in DHH children's discourse abilities.

An implication of these findings is that considering discourse skills at one level only may be insufficient to gain an insight into children's discourse abilities comprehensively. Discourse skills assessed at different levels, including the ability to generate global and local *coherence relations* in a story, are important for identifying the areas of children's performance that deserve greater attention in intervention. The procedure used to assess discourse skills also may affect children's performance. The use of structured picture sequences or retelling procedures may facilitate the story generation task (Duinmeijer et al., 2012), but it is likely to require good inferential and story comprehension skills (Carretti et al., 2013). These factors should be taken into account in assessment.

A second contribution of this study concerns the role of verbal working memory in explaining DHH children's difficulties with discourse production. The ability of DHH children to generate stories orally or in written mode is associated with their reading skills. However, the results of this study demonstrate that the ability to produce discourse is also significantly constrained by DHH children's poor verbal working memory and, in particular, poor verbal rehearsal skills (see also Arfé et al., 2014; Geers, Strube, Tobey, Pisoni, & Moog, 2011). Teaching DHH children how to construct good stories or expose them to the narrative genre through reading (Pakulski & Kaderavek, 2012) is necessary, but it may not be sufficient to help them develop storytelling skills that are appropriate to their age. Storytelling activities must also address the problem of children's poor verbal working memory. It is important to shape the child's discourse skills in an optimal learning environment in which the load on verbal working memory is reduced. For written production, active scaffolding during collaborative writing, along with facilitation procedures such as dictation and subsequent elaboration of the draft text (Albertini et al., 2014; Wolbers,

2008), seems to be promising as an avenue for intervention. Oral storytelling activities might be designed according to similar

principles of procedural facilitation, using retelling paradigms, or scaffolding of story construction.

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