FACTORS UNDERLYING DEAF CHILDREN'S POOR READING SKILLS IN A SHALLOW ORTHOGRAPHY

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Abstract

In two studies we explored the cognitive and linguistic profile of DHH poor readers who learned to read a shallow orthography (Italian). Study 1 involved fifty DHH children from 7 to 13 years: 25 children performed below norms in a reading comprehension test (Cornoldi & Colpo, 1998), 25 showed an appropriate performance for their age. All children had normal IQ and no additional disabilities. Their performance in tasks of speech perception, nonverbal reasoning, verbal working memory (forward and backward digit span), receptive vocabulary, word reading (accuracy and speed) and decoding (accuracy and speed) were compared. The results showed that the two groups differed in receptive vocabulary, backward digit span and word reading speed. Study 2 furthered the results of study 1. Sixty-two children (aged 7-12) were tested: 19 DHH poor readers, 21 reading-age matched hearing poor readers, and 19 school-age matched hearing good readers. We compared their performance at forward and backward reading span, phonemic awareness, productive vocabulary, and receptive grammar tasks. The results showed significant differences between good and poor hearing readers in their backward digit span (verbal working memory), vocabulary and phonemic awareness skills. DHH poor readers performed lower than hearing poor readers only in receptive grammar, and, differently from hearing poor readers, showed good phonemic awareness skills.

The causes of the reading comprehension problems of deaf and hard of hearing (DHH henceforth) children have been identified only partially and in most cases with reference to deep orthographies (mainly English) (Dillon & Pisoni, 2006; Kyle & Harris, 2010). In two studies we examined the factors underlying DHH children's failure in reading comprehension in a shallow orthography: Italian.

The Phonological and Non-phonological Components of Reading in Hearing and DHH Readers

The development of reading requires on the one hand acquiring the ability to decode, or convert letters into phonemes, on the other, the understanding of verbal language (Ouellette & Beers, 2010). According to the Simple View of Reading (Hoover & Gough, 1990), these two components, decoding and linguistic comprehension, are relatively independent and can be selectively impaired in readers.

Decoding requires phonological skills, such as phonological memory or phonological awareness (Dillon & Pisoni, 2006; Ouellette & Beers, 2010). Language comprehension involves processes that go beyond phonology, or non-phonological skills, which encompass semantics and vocabulary, syntax and grammatical skills, and the ability to comprehend discourse (Bishop & Snowling, 2004). In hearing poor decoders, phonological skills are poor, but non-phonological (semantics and syntactic) skills of linguistic comprehension are normal (Catts, Adlof, & Weismer, 2006). Since word recognition skills typically develop from decoding, these readers often show problems in both nonword reading, i.e. decoding, and in irregular word reading, that is, in word recognition (Catts et al., 2006). In hearing poor comprehenders, difficulties with semantics, syntax and discourse occur without any phonological impairment (Bishop & Snowling, 2004; Catts et al., 2006). These readers may show impairments in receptive vocabulary (Catts et al., 2006), grammatical understanding (Catts et al., 2006), discourse comprehension (Catts et al., 2006), but their reading problems are not related to poor decoding or word recognition skills (Bishop & Snowling, 2004; Catts et al., 2006).

It is not yet clear whether this distinction between phonological and non-phonological reading components can be helpful to describe DHH children's reading comprehension problems. The role that DHH children's poor non-phonological skills play in determining their reading comprehension problems is widely recognized (e.g. Kyle & Harris, 2010; Miller, 2010). However, the findings regarding the influence of DHH children's phonological skills on their reading comprehension are contrasting. Some studies indicate that these also affect DHH children's poor reading comprehension (Dillon & Pisoni, 2006; Johnson & Goswami, 2010), while other suggest that they do not (Izzo, 2002; Kyle & Harris, 2010).

As mentioned earlier, one of the limits of this research is that it has been largely restricted to English.

Study 1

Study 1 compared the cognitive-linguistic profiles of 50 Italian 7-13 year-old DHH readers who performed below (< 15th percentile) (n=25) or within normal limits (n=25) in a standardized reading comprehension assessment (Cornoldi & Colpo, 1998).

Participants

All the children were orally educated. Only children who showed a performance above the 15th percentile at progressive matrices (Raven, 1998) were included in the study. The two groups of poor and good DHH readers were matched for age, $F(1,48)= 2.08$, p=n.s., $\eta^2= .04$, and for their aided hearing threshold, $F(1,48)= 0.09$, p=n.s., $\eta^2= .00$

DHH poor comprehenders (PC). This group (n=25) included 11 girls and 14 boys, with a mean age of 10.4 years (SD=1.6, range 7-13). Their hearing loss ranged from moderate to profound. Eighteen children had a monolateral cochlear implant. The remaining children used digital hearing aids. The age at first compensation ranged from 12 to 84 months (M= 33.33, SD=24.19), and their aided threshold ranged from 25 to 45 dB (M=27.11, SD=7.6).

DHH good comprehenders (GC). This group (n=25) included 13 girls and 12 boys, with a mean age of 9.8 years (SD=1.8, range 7-13). Their hearing loss was from moderate to profound. Nineteen children used digital hearing aids, six used cochlear implants. The age at first compensation ranged from 6 to 156 months (M=44.9, SD=41.2), and their aided hearing threshold ranged from 15 to 45 dB (M=26.4, SD=7.5).

Procedure

In an individual assessment session, the children performed the following tasks:

Speech perception. A word identification test, the TIPI (Test Identificazione Parole Infantili) (Arslan, Genovese, Orzan, & Turrini, 1997), was used to assess speech perception skills. The test requires identification of a bi-syllabic word in a closed-set of four items.

Receptive vocabulary. The Peabody Picture Vocabulary Test- Revised was used to assess receptive vocabulary (PPVT-R, Italian standardization by Stella, Pizzoli, & Tressoldi, 2000).

Verbal short-term/working memory. The forward digit span and backward digit subtests of the WISC-IV (Wechsler, 2003) were used, as measures of the efficiency of the phonological loop (verbal short–term memory) and of verbal working memory respectively (Gathercole, Pickering, Ambridge, & Wearing, 2004; Pisoni & Cleary, 2003).

Nonverbal reasoning. Raven's progressive matrices (Raven, 1998) were used to assess nonverbal reasoning, as nonverbal skills have been shown to contribute to DHH children's reading comprehension (Daza, Phillips-Silver, Ruiz-Cuadra, Lopez-Lopez, 2014).

Decoding and word reading. The nonword and word reading subtests of the Battery for the Evaluation of Developmental Dyslexia and Dysgraphia (DDE-2, Sartori, Job, & Tressoldi, 2009) were used to assess decoding and word recognition for accuracy and speed.

Reading comprehension. A standardized reading achievement test (Cornoldi & Colpo, 1998) was used to assess text comprehension.

Results

PC and GC differed significantly for the degree of hearing loss: PC showed a greater hearing threshold than GC: F (1,48)= 10.03, $p<.005$, $\eta^2= .17$. However, the age at compensation did not differ between the two groups: F (1,48)= 1.07, p=n.s, $\eta^2= .03$.

A multivariate analysis of variance (MANOVA), with age and unaided hearing threshold as covariates, showed that the two groups differed significantly in their verbal working memory skills, i.e. backward digit span scores, F (1,46)= 9.67, $p<.005$, $\eta^2{}_p = .17$, receptive vocabulary, F (1,46)= 26.88, $p<.001$, $\eta^2{}_p = .37$, and word reading speed, F (1,46)= 8.60, $p=.005$, $\eta^2{}_p = .16$. The children's unaided hearing threshold did not explain differences in any of the dependent measures. Age accounted for differences in receptive vocabulary scores, F (1,46)= 14.62, $p<.001$, $\eta^2{}_p = .24$, and in nonword reading and word reading speed, respectively: F (1,46)= 16.57, $p<.001$, $\eta^2{}_p = .27$, and F (1,46)= 25.60, $p<.001$, $\eta^2{}_p = .36$.

Conclusions

Italian is a shallow orthography, which relies on phonological recoding strategies (Desimoni, Scalisi, & Orsolini, 2012).Therefore, if poor phonological processing skills play a significant role in DHH children's reading comprehension, this should have been evident when comparing the cognitive-linguistic profiles of the PC and GC in this study. However, significant differences between the two groups (PC and GC) were only found in their nonphonological skills: receptive vocabulary, verbal working memory and word reading speed. The differences in word reading speed, but not in nonword reading speed, can be interpreted as evidence of the impact of poor lexical strategies in reading.

These results were consistent with other emerging data showing a nonphonolgical deficit in the reading profile of DHH English poor comprehenders (see Kyle & Cain, in press), similar to that of hearing poor comprehenders.

Study 2

Study 2 aimed to further the results of Study 1, by directly comparing DHH readers and hearing poor comprehenders. In this Study we also examined the differences between DHH readers and hearing poor and good comprehenders in phonological awareness and receptive grammar. Prior research has shown that in DHH children these can be two critical factors of their poor reading comprehension (Johnson & Goswami, 2010; Miller, 2010).

Participants

Fifty-nine children (age 7-12) took part in Study 2: 19 DHH poor comprehenders (DHH PC), 21 reading-age matched hearing poor comprehenders (HPC), and 19 school age-matched hearing good comprehenders (HGC).

DHH poor comprehenders (DHH/PC). This group comprised 19 students (12 girls) from 7 to 12 years (M= 10.13; SD=1.6). All performed at or below the 15th percentile in a standardized reading comprehension task (Cornoldi & Colpo, 1998). Their clinical files reported no significant delays in word reading and nonverbal IQ within normal range (≥ 85). The age at diagnosis ranged from 3 to 36 months (M=21.6, SD=10.46). Their hearing loss ranged from moderate to profound. Eight children had one or two cochlear implants. Eleven children used digital hearing aids. All children used oral language and bimodal communication at school. All were receiving speech-therapy at the time of the study.

Hearing poor comprehenders (H/PC). This group included 21 children (7 girls) matched to the DHH poor comprehenders for school- age and reading level. Their age ranged from 6 to 12 (M=9.4, SD=1.9). All performed at or below the 15th percentile in a standardized reading comprehension task (Cornoldi & Colpo, 1998), and did not show decoding or word reading problems. Only children with no diagnosed or suspected cognitive impairment were included in this group.

Hearing good comprehenders (H/GC). This group included 19 children (nine girls) matched to the DHH poor comprehenders for school-age. Their age ranged from 7 to 11 (M=8.4, SD=1.2). All performed within the normal range in a standardized reading comprehension task (Cornoldi & Colpo, 1998). They were reported to perform on average or above average at academic tasks.

Procedure

Children were met individually and performed the following tasks:

Reading comprehension. The same standardized reading achievement test used in Study 1 was also used in this study (Cornoldi & Colpo, 1998).

Productive vocabulary. It was assessed by a standardized picture naming task (BVN, Bisiacchi et al., 2005).

Receptive grammar. A shortened version of the TROG (Bishop, 1982; Bisiacchi et al., 2005) was used to assess receptive grammar.

Short-term memory/Verbal working memory. The forward and backward digit span tasks of the WISC-IV (Wechsler, 2003) were used to assess verbal short-term and verbal working memory.

Phonemic awareness. An experimental picture-based, phonemes matching task (Arfé, Nicolini, & Pozzebon, 2014) was used to assess children's phonemic awareness skills. The task is administered orally and consists of matching two pictures/words out of four named aloud by the examiner. The words are matched either on the basis of their first (e.g. mano/hand; mela/apple) or medial (e.g. cane/dog; rana/frog) phonemes.

Task order was counterbalanced between participants.

Results

DHH/PC showed significantly poorer productive vocabulary and grammatical understanding than hearing GC: $F\,(1{,}37)= 9.50$, $p<.005$, $\eta^2_p = .20$, and $F\,(1{,}37)= 30.38$, $p<.001$, $\eta^2_p = .46$. Their forward digit span scores were also significantly lower than those of the H/GC, $F\,(1{,}37)= 8.39$, $p<.01$, $\eta^2_p = .18$. Effect size was larger for grammatical understanding than for productive vocabulary and for verbal short-term memory.

H/PC outperformed DHH/PC only in grammatical understanding: $F\,(1{,}37)= 21.63$, $p<.001$, $\eta^2_p = .37$, and forward digit span (verbal short-term memory), $F\,(1{,}37)= 10.82$, $p=.005$, $\eta^2_p = .23$. DHH/C's digit span backward (verbal working memory) and phonemic awareness were higher than those of the H/PC, though not significantly.

H/PC performed significantly below H/GC in productive vocabulary, $F(1{,}37)= 10.09$, $p<.005$, $\eta^2_p = .21$, and phonemic awareness, $F\,(1{,}37)= 14.33$, $p=.001$, $\eta^2_p = .28$. Their backward digit span scores were also lower, though the difference was not significant after Bonferroni corrections ($p=.02$).

Conclusions

DHH/PC did perform at the level of H/GC at the phonemic awareness task. However, their performance was significantly poorer when verbal short term memory was assessed (forward digit span). Forward digit span is believed to tap the verbal rehearsal mechanisms of verbal short term memory, and thus can be considered an index of phonological processing skills. A possible interpretation for these apparently contrasting findings is that some phonological skills (phonological memory) may contribute to DHH children's reading not through decoding but through their association with the nonphonological component of reading. Forward digit span is indeed a good predictor of vocabulary and grammatical development (Harris et al., 2013).

DHH/PC also showed a significant delay in comparison with the H/GC in all nonphonological reading components assessed in this study (vocabulary and grammatical understanding): However, grammatical understanding seemed to be the distinctive feature of their reading comprehension profile: DHH/PC and H/PC differed significantly in their grammatical skills.

Verbal working memory was a possible cause of the reading problems for the H/PC, but not for the DHH/PC.

Discussion

Although the distinction of the simple view of reading between phonological and nonphonological impairment is helpful for interpreting some of the reading comprehension problems of DHH poor comprehenders, it is not fully satisfying. DHH poor comprehenders' problems are not simply associated with poor non-phonological skills. The phonological component can also account for differences between these readers and hearing good readers. However, the role of phonological skills seems not to be related to poor phonological awareness or to poor decoding, as it happens in poor decoders. It seems rather that other phonological processing skills, those involved in verbal short term memory (verbal rehearsal), impact on reading, perhaps because they affect the linguistic understanding of the text.

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