READING COMPREHENSION IN DEAF CHILDREN:

THE IMPACT OF THE MODE OF ACQUISITION OF WORD MEANINGS

LOES WAUTERS

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Reading comprehension in deaf children:

The impact of the mode of acquisition of word meanings

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Loes Nel Wauters
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VOORWOORD

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INTRODUCTION

The aim of this thesis is to gain insight into reading comprehension processes in deaf children and adolescents in the Netherlands.[1] In the United States and Great Britain, the average reading comprehension score of deaf adolescents is found to stagnate at the level of 9-year-old hearing children (Allen, 1986; Conrad, 1979; Holt, Traxler, & Allen, 1997; Karchmer & Mitchell, 2003). What exactly causes this difference between deaf and hearing children[2] is yet to be clarified. One important difference in the development of deaf and hearing children is their language acquisition process. For hearing children, language is accessible from birth on. They gradually acquire language through the interaction with others. For deaf children, language is usually not immediately accessible. Most deaf children have hearing parents who, after having discovered that their child is deaf, have to decide which language they are going to use in communication: spoken language or sign language. Whichever choice is made, the deaf child's language acquisition will be delayed (Marschark, 2002). Spoken language is not accessible for the deaf child until he or she acquires some skill in speech reading and even then only a reduced amount of verbal information can be perceived. Sign language is not immediately available either, because parents will first have to acquire this language themselves before being able to use it in communication with their deaf child. These language acquisition differences between deaf and hearing children most probably lead to differences in reading comprehension. Most deaf children will have a less solid language base when they start reading. The focus of the present thesis will be on two major aspects of reading comprehension difficulties in deaf children as compared to hearing children. First, it will be shown that word identification processes only partly explain the

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[1] The exact number of deaf people in the Netherlands is unknown, but De Graaf, Knippers, and Bijl (1998) counted 347 deaf children without additional handicaps (hearing loss > 90 dB) between 6 and 12 years old in deaf education or mainstreamed in hearing education. No data are available for other age groups, but De Graaf et al. estimated the prevalence of hearing losses over 70 dB to be 0.74 per 1000 people (excluding people with a hearing loss as a result of aging). According to this estimation, 12.047 of the 16.280.048 people in the Netherlands are deaf or hard-of-hearing.

[2] Although adolescents also participated in the studies of this thesis, the term *children* will be used throughout the rest of this thesis.

differences between deaf and hearing children. Second, results of the studies in this thesis will show that the mode of acquisition of word meanings is a key factor.

Studies on reading processes in deaf children are scarce in the Netherlands and those that have been done have dealt almost exclusively with reading at the word level (IJsseldijk, 1989; Schaper, 1991). Broesterhuizen (1994) studied reading comprehension in a small group of deaf children and found them to read at a functionally illiterate level. Chapter 2 of this thesis describes the first large-scale study on reading comprehension of deaf children and adolescents in the Netherlands that was done to assess their level of performance and compare it to that of hearing children.

The subsequent chapters concentrate on two major component skills in reading comprehension namely, decoding and linguistic competence. Problems in reading comprehension can stem from poor decoding skills, poor linguistic competence, or a combination of both (Hoover & Gough, 1990). Decoding refers to word recognition; linguistic competence refers to the ability to extract semantic information from words and to derive sentence and discourse meaning. Reading comprehension is thought to involve the same linguistic competence as listening comprehension with the difference that in reading comprehension the process begins with print. Decoding and listening comprehension have been found to explain about 80% of the variance in reading comprehension (Carver, 1993; de Jong & van der Leij, 2002; Hoover & Gough, 1990). Researchers are still debating the exact relation between decoding and listening comprehension – e.g., whether it is a multiplicative or an additive relationship – but they agree on the explanatory power of the two components. Studying reading comprehension in deaf children with the emphasis on these two components seems therefore to be justified.

It is reasonable to expect word identification to cause difficulties for deaf children since letters in the alphabetic script represent the phonological form of the word. This alphabetic principle presupposes access to phonological information, which is obstructed when speech sounds cannot be heard and speech identification is dependent upon the incomplete information derived from speech reading. However, some deaf children, but not all, seem to have access to phonology and to use this information in reading (Perfetti & Sandak, 2000; Alegria, Leybaert, Charlier, & Hage, 1992). Whether and to what degree the difference in reading comprehension between Dutch deaf and hearing children can be explained by a difference in word identification skill is one of the topics in Chapter 2.

Gough, Hoover, and Peterson (1996) found the correlation between decoding and reading comprehension to decrease over grades, while the correlation between listening comprehension and reading comprehension increases over grades (cf. Perfetti, 1987). Gough et al. explain this by the fact that reading materials for the early grades are very simple, making reading comprehension at this level mainly dependent on decoding skill. In the higher grades, decoding has become an automatic process and texts deal with more difficult topics. Thus, reading comprehension in these grades will depend more on linguistic competence. Linguistic competence is a complex ability comprising various skills and forms of knowledge. The present study of the role of linguistic competence in reading comprehension concentrates on one central component of this competence: knowing the meaning of words. More specifically, the effect of the *mode of acquisition* of words will be examined. Mode of acquisition (MOA) is a new construct, introduced by Wauters, Tellings, van Bon, and van Haaften (2003; Chapter 3 in this thesis) referring to the way in which children (or adults) acquire the meaning of a word. It is based on the idea that concepts may consist of linguistic as well as non-linguistic (perceptual) meaning elements and that most concepts are a mixture of such elements (van Haaften, 1979; Tellings, 1995). Word meanings can be learned through perception of the referents of the words, through linguistic information (i.e., through verbal or written explanation, description, or discussion of the referents), or through a combination of both. For example, a child will learn the meaning of the word [ball] by connecting that word with a ball or the picture of a ball he or she sees. The meaning of [ball] is learned through perception. On the other hand, the meaning of the word [era] can be learned only through linguistic information. It will have to be explained to a child through language or it may be derived from conversations about an era. Most word meanings, however, are acquired through a combination of perceptual and linguistic information, as will be the case for a word like [caravan]. The meaning of this word may be explained by showing a picture of a caravan and telling a child that it is a house on wheels used to go on vacation. In these examples, the MOA is determined by the nature of its referents. For other words, the

MOA is dependent on the context of acquisition. Children may learn the meaning of a word in different ways as a consequence of the time and place of acquisition or even their culture and social economic status. The validity of the construct MOA is discussed in Chapter 3. This chapter further discusses whether texts in the successive grades of elementary school differ in the MOA of the words used.

Acquiring word meanings through linguistic information demands access to language. For many deaf children of hearing parents, language access is limited in the early years of life, because spoken language is inaccessible and sign language is not available. This limited access to language makes acquiring word meanings through linguistic information more difficult for deaf children than for hearing children. Therefore, deaf children's knowledge of these word meanings will be less comprehensive, which makes understanding texts containing such words relatively difficult. Deaf children's vocabulary knowledge is often found to be less than that of hearing children (Kelly, 1996; Marschark, Lang, & Albertini, 2002; Paul, 2003). However, it is not clear whether this difference is general or restricted to specific words. The present thesis investigates whether the vocabulary difference between deaf and hearing children is related to the MOA of words. Chapter 4 studies whether, for deaf and hearing children, the occurrence of words with strongly linguistic meanings in sentences leads to different reading times and comprehension scores as compared to words with strongly perceptual meanings.

Chapter 5 studies the relative strength of MOA as an explanatory factor in reading comprehension. The scope of the study is broadened to other skills and knowledge involved in linguistic competence in order to see which specific item characteristics influence deaf children's reading comprehension. Deaf and hearing children's answers in the multiple choice reading comprehension tests are analyzed to find out which underlying factors influence their performance and whether these factors differ for deaf and hearing children.

In closing, some general conclusions and a discussion of the results of this thesis will be presented in Chapter 6. In addition, some theoretical and practical implications will be sketched.

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READING COMPREHENSION OF DUTCH DEAF CHILDREN[3]

Abstract

In this study, the reading comprehension of deaf children and adolescents in the Netherlands is examined along with their word identification. The reading comprehension of 464 deaf students and the word identification of 504 deaf students between 6 and 20 years of age was examined. The results show the reading comprehension scores of deaf children to be far below the scores of hearing children. On average, the deaf participants scored at a level equivalent to a hearing child in the first grade. The word identification scores of the deaf children, however, were almost equivalent to the scores of hearing children. Although reading comprehension and word identification appear to be related, this relation does not completely explain the comprehension difficulties encountered by deaf children. Additional factors are required to explain deaf children's difficulties with reading comprehension.

Introduction

According to the Simple View of Reading (Hoover & Gough, 1990), reading comprehension consists of two components: decoding and linguistic comprehension. Decoding refers to efficient word recognition. Linguistic comprehension is "the ability to take semantic information at the word level and derive sentence and discourse interpretations" (Hoover & Gough, p.131). From such a perspective, reading difficulties can arise from decoding problems, comprehension problems, or a combination of both. According to Stothard and Hulme (1996), decoding and linguistic comprehension both are necessary to read but depend on different underlying skills. Decoding skill is closely related to phonological skill while linguistic comprehension depends upon general language skill (also see Bradley & Bryant, 1983; Caravolas, Hulme, & Snowling, 2001; Høien, Lundberg, Stanovich, & Bjaalid, 1995; Torgesen, Wagner, & Rashotte, 1997). In the present study, the reading comprehension of deaf children and the role of one of its determinants according to the simple view of reading, namely word identification, are examined.

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[3] Reference: Wauters, L. N., van Bon, W. H. J., & Tellings, A. E. J. M. (in press). Reading comprehension of Dutch deaf children. *Reading and Writing: An Interdisciplinary Journal.*

Again and again, deaf children's reading comprehension skill has been shown to be low. Furth (1966) investigated the reading comprehension of deaf students between 15;6 and 16;6 years of age and found a grade 3.5 level on average. Conrad (1979) found a mean reading age of 9 years among profoundly deaf students between 15;0 and 16;6 years of age. Only 5 of the 205 participants in Conrad's sample read at an age-appropriate level. Allen (1986) studied the reading performance of deaf students between 8 and 18 years of age and detected a leveling off at the third grade level. That is, the 15-, 16-, and 17-year-olds show a third grade level of reading on average while the average reading level for the 18-year-olds was just below the third grade level. According to Allen, this leveling off may be due to the fact that the better performing students simply move out of special education. Whether this is the case or leveling off actually occurs is unclear from Allen's study, however.

More recent studies have shown the reading performance of deaf students to be around the fourth grade level. Holt (1993), for example, found the median score of 17-year-old students with a profound hearing loss to be at a 3.8 grade level. Holt, Traxler, and Allen (1996) found the median reading comprehension score for the 17- and 18-year-olds in their sample to correspond to a fourth grade level. The median scores of the deaf and hard-of-hearing participants in the norming sample for the 9th edition of the Stanford Achievement Test fall into the "below basic" level or lowest of four levels (Traxler, 2000), which means from the age of 13 on a grade equivalent between third and fourth grade. The 80th percentile for the deaf sample lies between the hearing "basic" and "below basic" levels. It should be noted that some of the deaf and hard-of-hearing students performed at a similar level as their hearing peers but that the number of deaf and hard-of-hearing students achieving at the level of their hearing peers was found to decrease with age (Traxler, 2000).

According to the simple view of reading, word identification is one of the components that determine reading comprehension. For hearing children, the development of word identification depends on phonemic awareness (Adams, 1990; Bradley & Bryant, 1983; Caravolas et al., 2001; Høien et al., 1995; Torgesen et al., 1997). That is, phonological decoding is based on the alphabetic principle that letters represent the phonological form of the word. If spoken language is not accessible, as is the case for most deaf children, access to phonological information is obviously obstructed and deaf children's word identification can be expected to be low.

A few studies have shown some but not all deaf students to actually have access to phonology and to use this information to read (Perfetti & Sandak, 2000; Alegria, Leybaert, Charlier, & Hage, 1992). Deaf readers can access phonological information via a combination of speechreading, finger spelling, articulation, and exposure to writing although none of these alone appears to be sufficient (Leybaert, 1993; Padden & Hanson, 2000; Marschark & Harris, 1996; Marschark, et al., 2002). The ability to use phonology appears to be related to the degree of hearing loss, speech intelligibility, and reading level (Leybaert, 1993; Perfetti & Sandak, 2000). Although some deaf people have access to phonological information, many others show slow and inaccurate decoding skills (Knoors, 2001).

Hanson and Fowler (1987) have shown deaf college students with good reading comprehension skill to clearly access phonological information. The authors used a lexical decision task in which the participants had to decide whether two strings of letters were both English words or not. The results showed phonologically similar words to facilitate the lexical decision process for both deaf and hearing students, which indicates the use of phonological information and word identification based on such information. The mean error percentages showed that the deaf participants made more errors than the hearing participants, and the authors remarked that the deaf subjects made more errors than the hearing participants on a rhyme judgment task requiring subjects to indicate whether two written words rhyme or not.

Although many studies have examined the capacity of deaf subjects to access phonological information, little is known about their level of word recognition. A number of studies have shown limited word recognition skill on the part of deaf children. In a longitudinal study, for example, Harris and Beech (1998) found significant differences in the word recognition of deaf versus hearing children. When asked to match written words to pictures, the 4- to 6-year-old deaf children scored significantly lower than their hearing peers. However, phonological awareness was found to be an important predictor of reading gain for not only the hearing but also the deaf children.

Merrills, Underwood, and Wood (1994) compared the word recognition skills of 11- to 15-year-old deaf students with the skills of hearing students with: 1) good reading comprehension skill, 2) poor reading comprehension skill but still a little higher than that of the deaf students, and 3) a matched reading comprehension age group. On a lexical decision task, the deaf students responded more slowly and less accurately than the hearing students with good reading comprehension. However, they responded faster and more accurately than the reading comprehension age-matched hearing students. No significant differences were found for the deaf versus hearing students with poor reading comprehension. The authors conclude from these results that word recognition problems are thus not sufficient to explain the reading comprehension difficulties encountered by deaf children.

In their study of word coding skills, Burden and Campbell (1994; see also Campbell & Burden, 1995) found deaf students with a mean age of 14 years and 6 months to perform equally to chronologically age-matched hearing controls on a lexical decision task. Both the deaf and hearing students performed faster and more accurately than the younger hearing students with the same reading age as the deaf students. In all of the groups, moreover, high frequency words were processed faster and more accurately than low frequency words.

Beech and Harris (1997) found deaf students to perform at a similar level as hearing students on a word reading task. However, the deaf students were older than the hearing students due to matching according to reading age and the authors argue that "it is highly unlikely that most of the deaf participants in this study will progress in reading at the same rate as the younger hearing children" (p. 117).

Fischler (1985) found no differences in the latency or accuracy of the responding of deaf versus hearing graduate students on a lexical decision task, which indicates adequate word identification among the deaf subjects. These results suggest that "at least at college age, difficulty in recognizing known words may not be a major factor in determining overall reading skill for the deaf" (Fischler, 1985, p. 214).

According to the simple view of reading (Hoover & Gough, 1990), deaf children's reading comprehension difficulties can be explained in terms of decoding problems, linguistic comprehension problems, or both. In the present study, the reading comprehension of deaf students in the Netherlands and the role that word identification appears to play in their reading comprehension were therefore examined. If the word identification skills of deaf students are found to be low, then at least a partial explanation for their low reading comprehension has been found; if the word identification skills of deaf students are found to be adequate, then the explanation for their low reading comprehension must lie in poor linguistic comprehension.

Poor linguistic comprehension may be caused by the absence of various kinds of knowledge, including syntactic and semantic knowledge (Musselman, 2000). When Hoover and Gough (1990) assessed linguistic comprehension in the form of listening comprehension, they found the linear relation between listening comprehension and reading comprehension to increase as the level of decoding skill increased. Apparently, as text decoding becomes more adequate, linguistic competence as evidenced by listening comprehension becomes the major determinant of written text comprehension. In hearing adults, a high correlation is generally found between listening comprehension and reading comprehension (Snow, Burns, & Griffin, 1998). In children, however, this correlation develops across elementary school and listening skill surpasses reading skill up until Grade 7. From then on, listening and reading comprehension may be equal or reading comprehension may even exceed listening comprehension (Snow et al, 1998; Sticht & James, 1984). According to Snow et al. (1998), thus, “the high correlations between listening and reading comprehension occur after a child has learned how to decode” (p.˚64). And when a reader’s decoding skills are thus adequate, reading comprehension difficulties can only stem from listening comprehension, that is, from linguistic deficiencies.

Not much is known about the reading development of deaf children in the Netherlands and the differences between deaf and hearing children with respect to reading performance. For this reason, the present study determines the reading comprehension levels of as large a part as possible of the population of deaf children in primary and secondary education in the Netherlands for subsequent comparison to the reading comprehension of their hearing same-age peers. According to studies from the US and Britain (Allen, 1986; Conrad, 1979; Holt, 1993; Holt et al., 1996), deaf children can be expected to perform at a lower level than hearing children. More specifically and in keeping with the leveling off detected by Allen (1986), a mean level of third grade can be expected for the reading comprehension of deaf students.

The role of word identification in the reading comprehension of deaf children will next be investigated. In the studies by Harris and Beech (1998) and Merrills et al. (1994), the word identification of deaf children was found to be poorer than the word identification of hearing peers. However, Fischler (1985) found no significant differences between deaf and hearing college students on a lexical decision task, and Burden and Campbell (1994) similarly found deaf 14-year-olds to perform equally well as their hearing peers on a lexical decision task. On the basis of the above findings, at least the younger deaf children in the present study are expected to show lower word identification skill than their hearing peers. This study investigates whether the word identification differences between at least the younger deaf and hearing students can explain the differences in their reading comprehension.

In a third set of analyses, the possible differences between the reading comprehension of deaf children with deaf parents (i.e., deaf-deaf children) and deaf children with hearing parents (i.e., deaf-hearing children) will be explored. Whereas the deaf parents of deaf children are probably able to communicate adequately with their children from a very early age, the hearing parents of deaf children usually experience a delay of a few years in the development of their ability to communicate adequately with their deaf child. While it is simply not known whether all deaf parents communicate with their children using sign language or some of them use speech or a form of manually coded speech, the language development of deaf-deaf children can nevertheless be expected to start earlier and expand more smoothly than the language development of deaf-hearing children. While a head start with regard to language development will presumably facilitate the development of various literacy, cognitive, and social skills, the evidence for an advantage of deaf-deaf children over deaf-hearing children is inconsistent at best. Some studies have shown the reading comprehension of deaf-deaf children to be better than the reading comprehension of deaf-hearing children (Padden & Ramsey, 1998; Singleton, Supalla, Litchfield, & Schley, 1998). Other studies suggest that the presence of deaf parents is not a strong determinant of better reading comprehension on the part of deaf children (Akamatsu, Musselman, & Zwiebel, 2000; Strong & Prinz, 1997). Two of the four best readers in the study by Harris and Beech (1998) came from a hearing family and showed good language comprehension. The other two best readers came from a deaf family and showed both good signing and language comprehension. In other words, good language skills – whether oral or manual – appear to be important for reading success. Luetke-Stahlman (in Musselman, 2000) has also concluded that it is not the particular language used but the completeness of the linguistic representation that promotes reading success. Stated differently, the ability to communicate from an early age appears to be a more important factor than having deaf versus hearing parents (Akamatsu et al., 2000; Marschark, Lang, & Albertini, 2002). In addition to the examination of the influence of having deaf versus hearing parents in the present study, the roles of such factors as age, IQ, degree of hearing loss, ethnicity, educational language, home language, type of education, and level of education will be examined.

Method

Participants

Of the original 551 deaf participants, 47 had a cochlear implant (CI).[4] These participants were excluded from the present analyses, which leaves a total of 504 participants (269 boys and 235 girls) with a hearing loss of 80 dB or more between the ages of 6;7 and 20;1 years (mean = 12;9 years). Of these, 81 were in schools for hard-of-hearing children or were in mainstream education, and 423 were in schools for the deaf, representing about 90% of the population of deaf children without additional handicaps in deaf or mainstream education within this age range.

The mean instructional age, which refers to the school achievement of the child defined as the number of years of formal instruction (starting in first grade), was 7 years.

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[4] A cochlear implant is a hearing aid with an external and an internal part. The external part receives sounds and translates those into an electric code. The internal part converts these electric codes into signals to be communicated to the hearing nerve through electrodes. A cochlear implant permits better perception of speech sounds and increases access to the segmental features of speech, which improves spoken linguistic performance.

Given that reading instruction for deaf children does not always start at the same time as reading instruction for hearing children, the use of instructional age was considered more valid than the use of chronological age. An instructional age of 1 year thus means that the child has had 10 months of formal instruction. In the Netherlands, deaf education students usually attend school until the age of at least 16, which usually corresponds to an instructional age of 10 years; thereafter, education is no longer compulsory. Although a selection bias cannot occur for the group of participants in compulsory education, Allen's (1986) problem of a cross-sectional sample may hold for the participants over the age of 16.

Table 1. Characteristics of the deaf participants.

	Number of students
Gender	
Female	235
Male	269
Onset of deafness	
Before the age of 3	452
After the age of 3	29
Missing values	23
Parents	
Both deaf	15
Both hearing	466
Hearing + deaf	9
Both hard-of-hearing	1
Deaf + hard-of-hearing	3
Hearing + hard-of-hearing	3
Missing values	7
Ethnicity	
Dutch	394
Other	97
Dutch and other	6
Missing values	7
Current education	
Deaf	423
Mainstream	35
Hard-of-hearing	46
Educational level	
Primary education	233
Secondary education	271

The mean IQ of the participants was 97 (with a range of 59 to 144). The hearing losses ranged from 80 to 140 dB (M = 108 dB). In Table 1, an overview of the characteristics of the participants studied here is presented. While most deaf children in the Netherlands are in deaf schools that use both spoken and sign language, one of the schools included in the present study used only spoken language. Mainstreamed deaf students are usually educated in the spoken language. In Table 2, an overview of information provided by the teachers of the subjects with regard to the language used at school and the language used at home is presented. Of the teachers using signs, 61% used Sign Supported Dutch[5], 14% used the Sign Language of the Netherlands[5], and 25% used a combination of both.

Table 2. Language used at school and at home as percentage of students approached using that language.

	Students in schools for the deaf or hard-of-hearing		Students in mainstream education	
Language used	School[a]	Home[b]	School[a]	Home[b]
Spoken language only	14.0	21.9	81.3	81.8
Mostly spoken language, some signs	9.8	38.6	6.3	6.1
As much spoken language as sign language	37.6	24.7	12.5	9.1
Mostly signs, some spoken language	32.4	12.0		3.0
Sign language only	6.2	2.8		

[a]School language information was available for a total of 482 participants.
[b]Home language information was available for a total of 458 participants.

All of the schools for the deaf mainstream students gave permission to administer a word identification test to the hearing classmates of the deaf students. In such a manner, comparison data were collected for 1475 hearing participants (about 50% male and 50% female) between the ages of 5;9 and 19;3 years (mean = 10;1). Of the hearing

[5] Sign Supported Dutch uses the grammar of spoken Dutch and the signs from the Sign Language of the Netherlands. In using Sign Supported Dutch, people speak and sign simultaneously. The Sign Language of the Netherlands has its own grammar that is not based on spoken Dutch.

participants, 1127 were in primary education and 348 in secondary education. All grades of primary and secondary education were represented in the sample.

A comparison of the deaf and hearing participants showed the deaf participants to be an average of 2;8 years older than the hearing participants ($t(1372) = 17.04$, $p < .001$). The mean instructional age of the deaf participants ($M = 7$, $sd = 3.3$) was also higher than that of the hearing participants ($M = 5$, $sd = 2.5$; $t(1933) = 18.18$, $p < .01$).

Materials

Word identification

As in other studies (Fischler, 1985; Hanson & Fowler, 1987; Merrills et al., 1994), a lexical decision format was used to assess word identification. Two lexical-decision tests were used in the present study. Based on the word decoding test, as developed by van Bon, Tooren, and van Eekelen (2000), the silent-reading test was composed for use in the present study. The silent-reading test consists of 160 letter strings: 40 real words and 120 pseudowords. The group of real words consists of 30 nouns, 5 adjectives, 4 homonyms that can be either a noun or an adjective, and 1 adverb. All of the real words are highly frequent monosyllabic CVC-, CV-, or VC-strings. The group of pseudowords consists of orthographically legal but non-existent (Dutch) word strings constructed by taking an additional real word and changing the vowels or consonants. For example, the Dutch word “*diep*” [deep] is changed into the meaningless string “*daap*”.

Each child is asked to read the strings column by column and cross out as many pseudowords as possible in one minute. While the original word decoding test involves a word-pseudoword ratio of 3:1, we decided to use a ratio of 1:3 for the silent-reading test with the group of real words restricted to more familiar words. The score for the silent-reading test is the number of items judged correctly. For hearing children, the scores on the silent-reading test are known to correlate highly with the scores on another commonly used word identification test requiring children to read words out loud (van Bon et al., 2000).

A potential disadvantage of the silent-reading test is that children may underestimate their vocabulary and therefore tend to accept pseudowords as real. Deaf children in particular may be insecure about their word knowledge. To avoid this disadvantage, we developed an additional word identification test, the *two-choices test*, with 80 items, each containing one real word and one pseudoword. The child should read the items column by column and cross out the pseudoword of each item. The score is the number of items judged correctly in one minute. The real words in this test were 62 nouns, 3 adjectives, 1 verb, and 14 homonyms that could be either a noun or an adjective. All of the real words were highly frequent monosyllabic CVC-, CV-, or VC-strings. The pseudowords were derived from the real words in the same manner as for the silent-reading test. By administering both the silent-reading test and the two-choices test, we could – given the validity of the silent-reading test – validate both tests against one another.

Reading comprehension

The reading comprehension of the deaf participants was measured using the Reading Comprehension Tests commonly used to evaluate hearing elementary school children (*Begrijpend Leestests;* Aarnoutse, 1996). Each grade has a different test consisting of 10 reading texts and a total of 25 to 30 multiple-choice questions with regard to the texts (and a total of four response alternatives) (see Appendices A and B for a sample text and the corresponding questions for Grades 1 and 6). No time limit is set for completion of these tests. All tests are reported by Aarnoutse to have a high reliability in terms of internal homogeneity, varying from .83 to .85. The raw score on each test is the number of correct answers. Each student's raw score is then converted into a latent score representing the level of performance along a scale provided by the Nijmegen Pupil Monitoring System (Aarnoutse et al., 2000), which encompasses the scores on all Reading Comprehension Tests for the various levels of primary education and beyond. The model parameters from a multi-sample LISREL analysis and the Kalman filter are used to estimate the latent scores for the Reading Comprehension Test from the raw scores (Oud, Jansen, van Leeuwe, Aarnoutse, & Voeten, 1998; Oud, van Leeuwe, & Jansen, 1993). The use of latent scores made it possible to include the data from older deaf students taking a test usually administered to younger hearing children.

Procedure

All of the participants completed both word identification tests. Only when the raw score on the two-choices test was 11 or higher was the child considered capable of completing a Reading Comprehension Test. This criterion was included to prevent the unnecessary administration of a Reading Comprehension Test and unnecessary frustration of certain children.

The judgments of the individual teachers were used to determine the appropriate Reading Comprehension Test for each participant. When the child scored lower on the selected test than the first decile for the original hearing norm group, the next lower level of test was administered. Similarly, when the child scored above the eighth decile for the original hearing norm group, the next higher level of test was administered.

All of the tests were administered by the teacher in the classroom. In the case of deaf students in mainstream education, the Reading Comprehension Test was administered individually by the student's itinerant teacher.

Results

Whether the development of the deaf children's reading comprehension differed significantly from the development of the hearing children's reading comprehension was first examined. More specifically, whether the reading comprehension of particularly the deaf children was found to level off or not was examined. In the next set of analyses, whether or not low levels of word identification contributed to the low reading comprehension of the deaf children was examined. And in a final set of analyses, the reading comprehension and word identification of the deaf children of hearing versus deaf parents were compared.

Reading comprehension

Of the 504 deaf participants included in the present study, 14 did not reach criterion on the two-choices test and were therefore not administered the Reading Comprehension Test. An additional 26 participants did not complete the Reading Comprehension Test due to illness or such. This left a total of 464 deaf participants who completed a version of the Reading Comprehension Test. The mean scores and standard deviations for the 464 deaf subjects completing the Reading Comprehension Test and the grade levels corresponding to these scores are presented in Table 3 according to increasing instructional age. As can be seen from Table 3, the elementary grade levels corresponding to the mean scores of the deaf children on the Reading Comprehension Test are strikingly lower than one would expect from their instructional ages.

Table 3. Mean latent scores for different instructional ages.

Instructional age	*N*	*M*	*sd*	Elementary grade level corresponding to *M*[a]
1	2	18.57	3.33	< Grade 1
2	14	18.23	2.34	< Grade 1
3	31	17.91	2.52	< Grade 1
4	40	19.84	3.68	Grade 1
5	44	20.39	4.43	Grade 1
6	25	20.30	5.09	Grade 1
7	65	22.16	4.99	Grade 1
8	49	22.93	5.60	Grade 1
9	53	23.05	4.10	Grade 1
10	38	23.79	4.99	Grade 2
11	36	24.11	5.05	Grade 2
12	19	25.81	5.91	Grade 3
13	35	25.88	5.95	Grade 3
14	5	22.55	4.37	Grade 1
15	4	23.80	4.92	Grade 2
16	2	18.70	0.91	< Grade 1
17	1	29.38	0.00	Grade 5
Total	463	22.19	5.18	Grade 1

[a] If *M* falls one *sd* below or one *sd* above the mean for a particular grade level, it falls outside that grade level. If *M* falls within the overlapping area for two grades, it is assumed to reflect the higher grade.

The mean latent scores for the instructional ages of 1 to 6 for hearing children are provided by the manual for the Reading Comprehension Tests. The scores for the instructional ages of 7 to 10 have been derived by extrapolation. Given that the scores for an instructional age over 10 could not be reliably estimated, we pooled the scores for those participants with an instructional age over 10.

Given a mean instructional age of 7 years for the deaf students, a mean seventh grade reading score could be expected ($M = 33.36$). However, the mean reading score ($M = 22.20$; $sd = 5.19$) for the total group of deaf participants was found to be only equivalent to the mean reading score for first grade hearing children ($M = 22.50$; $sd = 2.85$). In fact, the median score of 21.11 fell just below the average first grade latent score (i.e., within one *sd* below). This shows only 50% of the deaf participants to read at a first grade level or above. The highest 25% of the deaf participants read at a third grade level or above while – according to their instructional age – 91.8% of the deaf participants should read at this level or above.

In Figure 1, the distributions of the mean reading comprehension scores according to the instructional ages for the hearing and deaf students are depicted. T-tests for each instructional age[6] show the deaf children studied here to score lower than hearing children of the same instructional age ($p < .01$). However, as can be seen in Figure 1, this does not mean that none of the deaf participants scored at the level of hearing children of the same instructional age. When less than one sd from the mean for the norm group is taken as the criterion, 20 of the 464 deaf participants are found to read at the same level as hearing children of the same instructional age.

Some 19% of the 417 deaf participants with an instructional age of more than three years scored above the level of hearing third graders. This finding shows that a leveling off after third grade, as might have occurred in Allen's study (1986), did not occur in the present study. In fact, Figure 1 shows no upper limit on the reading comprehension scores of the deaf participants at any instructional age: The mean and median scores of the deaf students continued to increase across the years. Formulated differently, the mean reading score for the deaf readers with the most reading experience (i.e., an instructional age of 10 or higher) did not exceed that for second-grade hearing children although no upper limit on the reading scores of the deaf students was found; for 4.3% of the deaf participants, moreover, their reading level clearly corresponded to their instructional age.

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[6] For the instructional age of one year, involving only two deaf participants, no analyses were done.

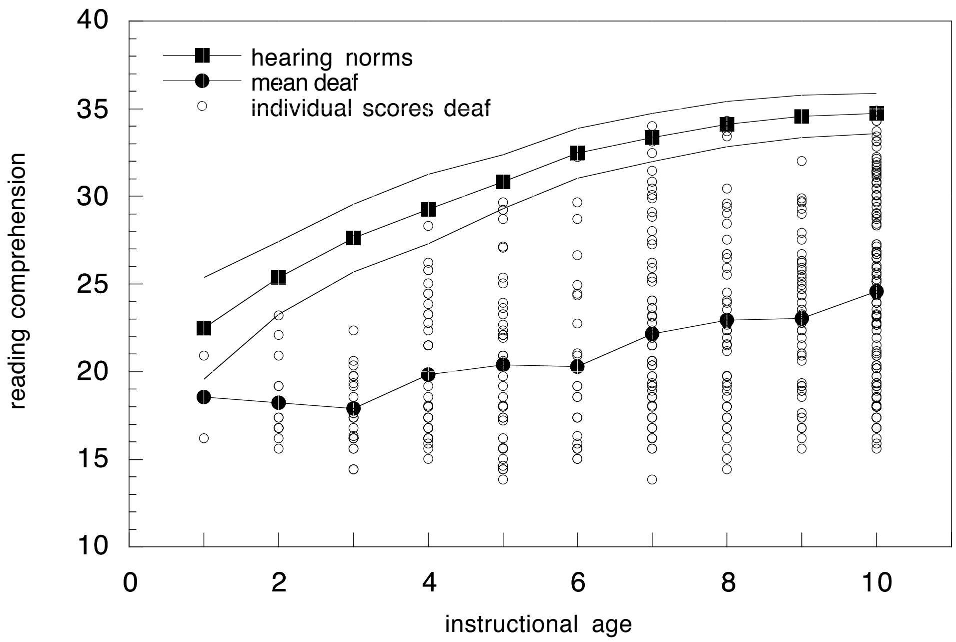

Figure 1. *Mean and median reading comprehension scores for the deaf participants at various instructional ages compared to norms for hearing children. The lines below and above the hearing norms delimit the range within one standard deviation of the mean.*

Those deaf participants who scored above the third-grade level differed significantly from the deaf participants who scored below this level with respect to the following characteristics. Their mean age was 2.5 years higher (14;11 versus 12;6); their mean IQ was higher (M =106, sd = 16.3 vs. versus M = 95, sd = 14.8); and the degree of their hearing loss was slightly lower (M = 105, sd = 10 vs. M = 109, sd = 12). Chi-square tests showed the two groups to also differ with respect to the following characteristics: ethnicity ($\chi^2(2) = 12.94$, $p < .01$), type of current education (deaf, mainstream, or hard-of-hearing education) ($\chi^2(2) = 36.91$, $p < .001$), educational level (primary or secondary education) ($\chi^2(1) = 34.30$, $p < .001$), educational language ($\chi^2(4) = 21.99$, $p < .001$), and home language ($\chi^2(4) = 20.18$, $p < .001$). Only a small percentage of the better reading group of deaf participants came from an ethnic minority group (5% vs. 22%). Conversely, a higher percentage of the better reading group of deaf participants came from mainstream classes (23% versus 4%) and most of them were in secondary education (85% versus 49%). Finally, the educational language for the deaf participants reading above the third grade level consisted of more spoken language than the educational language for the deaf participants reading below this level (28% versus 16%). The same pattern of findings was found for the home language of the different deaf participants (46% versus 22%).

Table 4. Summary of the first and final step in the backward logistic regression analysis for variables predicting reading score above third grade level (N = 243).

Variable (*reference category)*	Step 1 B (SE B)	Step 6 B (SE B)
Age	.031 (.012)**	.039 (.009)****
IQ	.025 (.018)	.029 (.017)*
Hearing loss	-.019 (.023)	
Current education (*hard-of-hearing*)		
Deaf education	-2.99 (.959)***	-2.71 (.854)***
Mainstream education	1.11 (1.35)	.451 (1.09)
Educational level (*secondary education*)	-1.26 (1.02)	
Ethnicity (*non-Dutch*)	1.79 (.880)**	1.68 (.801)**
Parents' hearing status (*deaf*)	.466 (3.93)	
Educational language (*signs only*)		
Spoken language only	-.507 (1.47)	
Mostly spoken language	-1.01 (1.56)	
Spoken and sign	.329 (1.28)	
Mostly signs	-.067 (1.25)	
Home language (*signs only*)		
Spoken language only	-1.29 (4.00)	
Mostly spoken language	-1.03 (3.94)	
Spoken and sign	-1.06 (3.91)	
Mostly signs	-2.30 (4.07)	
N	243	243
Chi^2 (degrees of freedom)	51.18 (16)***	44.50 (5)***

* $p < .10$, ** $p < .05$, *** $p < .01$, **** $p < .001$

Table 4 presents the results of the first and the final step in a backward logistic regression analysis with age, IQ, degree of hearing loss (dB), current education (deaf, mainstream, or hard-of-hearing education), educational level (primary or secondary), ethnicity (Dutch or non-Dutch), parents' hearing status (both deaf or both hearing), educational language, and home language as potential predictors and reading above third grade level as the criterion. Educational and home language both consist of five categories: spoken language only, mostly spoken language and some signs, as much spoken language as sign language, mostly signs and some spoken language, only sign language. For all non-continuous variables, the last category is the reference category. Table 4 shows the variables age, type of current education, ethnicity, and – to only a minor extent – IQ to independently determine which deaf children read above and which children read below a third-grade level ($\chi^2(5) = 44.5$, $p < .001$). Older deaf children of Dutch ethnicity have a better chance of reading above third grade level. Having a high IQ further helps in achieving this reading level. Children who are in deaf education are less likely to read above third grade level than children in hard-of-hearing or mainstream education.

The reading comprehension of deaf students raised with spoken language only was next compared to the reading comprehension of deaf students raised with sign language only. Students raised with only spoken language in the home scored better than students raised with only sign language in the home ($t(116) = 2.11$, $p < .05$). However, it should be noted that the students raised with only spoken language in the home were approximately two years older (M = 13;4) than the students raised with only sign language in the home (M = 11;6; $t(130) = 1,99$, $p = .049$).

Word identification

As already mentioned, two tests for word identification were administered to groups of both deaf and hearing participants. The high correlation of .85 ($p < .01$) between the scores on the silent-reading test and the scores on the two-choices test show the tests to be virtually equivalent. For the sake of brevity, therefore, only the data from the two-choices test were analyzed.

In Figure 2, the mean scores on the two-choices test for both the deaf and hearing participants are plotted along with the individual scores for the deaf participants. The mean scores for the deaf participants in both primary and secondary education were significantly lower than the mean scores for the hearing participants in primary and secondary education ($F(1,1241) = 12.50$, $p < .001$; $F(1,519) = 23.43$, $p < .001$). The mean scores for the deaf versus hearing participants in primary versus secondary education are also presented in Table 5.

Table 5. Mean scores on the two-choices test for deaf and hearing participants in primary and secondary education.

	Deaf			Hearing		
	N	*M*	*sd*	*N*	*M*	*sd*
Primary	233	25.55	12.19	1009	29.46	16.30
Secondary	271	42.55	15.16	250	48.82	14.32

The mean score on the two-choices test for the deaf primary and secondary education students combined (M = 34.63, sd = 16.29) was comparable to the mean score for the fifth grade hearing students (M = 34.41, sd = 8.74) and roughly comparable to the mean score for all of the hearing primary and secondary education students combined (M = 33.34, sd = 17.66).[7] The median of 35.0 for the deaf participants was comparable to the median for fifth grade hearing participants, which shows 50% of all the deaf children studied here to score at or above the fifth grade level for word identification. The highest scoring 25% of the deaf participants scored at or above the sixth-grade level for word identification, and some 78% of the 436 deaf participants with an instructional age of more than three years scored above the third-grade level.

One-way ANOVAs showed the word identification of deaf subjects with an instructional age of three years to be significantly lower than the word identification of hearing subjects with a comparable instructional age ($p < .05$). Similarly, the word identification of deaf subjects with an instructional age of five or more years was found to be significantly lower than the word identification of hearing subjects with comparable instructional ages (all $p < .01$).

Just as for reading comprehension, we found the word identification of deaf students raised with only spoken language in the home to be better than the word identification of deaf students raised with only sign language in the home ($t(130) = 2.17$, $p < .05$).

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[7] Analyses revealed the same result when the data from the silent-reading test were used. For the sake of brevity, these analyses are not reported here.

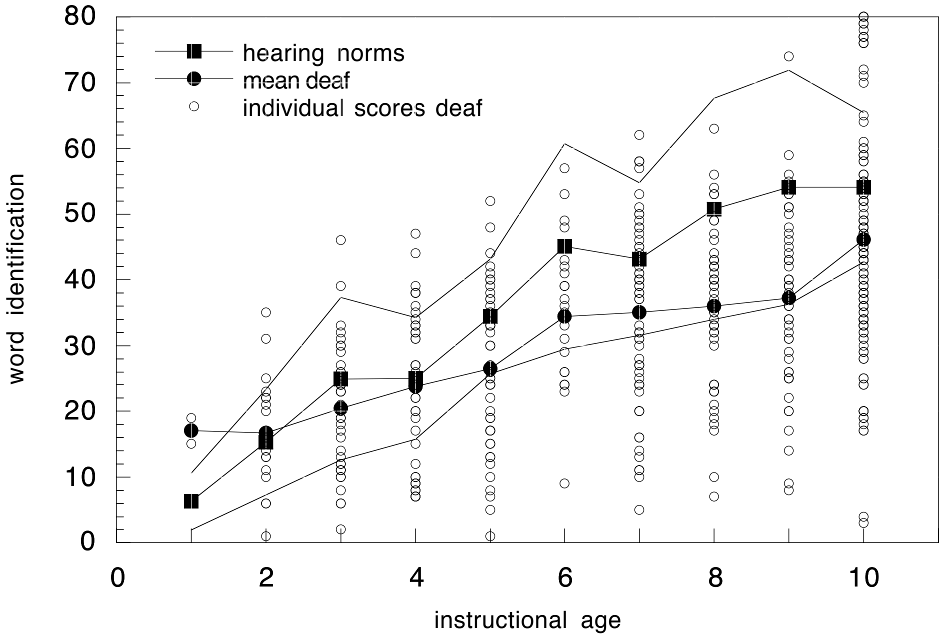

Figure 2. *Mean and median scores for the deaf participants on the two-choices test compared to the mean scores for hearing participants. The lines below and above the mean scores for the hearing participants depict the range within one standard deviation of the mean.*

Word identification and reading comprehension

The preceding results show the differences between the deaf and hearing groups to be smaller for word identification than for reading comprehension. This finding suggests that the low reading comprehension scores of the deaf subjects are not completely explained by their low scores for word identification. In order to test this possibility, the relations between the word identification scores of the deaf participants and their reading comprehension scores were examined.

As expected, a significant correlation was found between word identification and reading comprehension ($r = .50$, $p < .01$). Significant linear ($F(1,462) = 232.2$, $p < .001$) and quadratic ($F(2,461) = 126.3$, $p < .001$) components were found in the regression of reading comprehension on word identification. The quadratic component pointed to a diminishing increase of reading comprehension scores with increased word identification.

On the basis of the relation between instructional age and word identification skill for hearing children, the expected word identification scores for the deaf participants studied here were calculated using their instructional age. The expected scores proved higher than the observed scores ($t(503) = 14.2$, $p < .01$), which suggests that – even though the mean word identification performance of the deaf students was equivalent to the mean performance of the hearing participants – the word identification scores of the deaf participants should have been higher to be in accordance with their instructional age.

The expected word identification scores were next used to calculate the expected reading comprehension scores for the deaf students studied here. Using the observed word identification and reading comprehension scores for the deaf students, the relation between their word identification and reading comprehension was calculated via quadratic regression. The expected word identification scores calculated above were then imported into the regression formula to calculate the expected reading comprehension scores. The expected reading comprehension scores here are thus the reading comprehension scores that can be expected when the deaf participants produce the word identification scores expected on the basis of their instructional age. The expected reading comprehension scores calculated in such a manner were found to be significantly higher than the observed reading comprehension scores ($t(463) = 8.3$, $p < .001$), which suggests that the deaf participants would have better reading comprehension scores if their word identification scores were in accordance with their instructional age. However, the reading comprehension scores calculated on the basis of the expected word identification scores of the deaf subjects were significantly lower than the reading comprehension scores expected on the basis of the instructional age of the deaf participants ($t(463) = 446.8$, $p < .001$). This result shows the lower word identification skill of deaf children to indeed have a negative effect on the reading comprehension of such children. However, the relation between text comprehension and word identification appears to be such that the reading comprehension of deaf children may be still lower than that of hearing children even when the word identification skills of the deaf children are at an appropriate instructional-age level. In addition to word identification factors, thus, other factors appear to hinder the reading comprehension of deaf children.

Deaf or hearing parents

It is sometimes asserted that early access to language (in most cases: sign language) may lead to better literacy skills on the part of deaf children of deaf parents. The present study included a total of 466 deaf children of hearing parents (i.e., deaf-hearing children) and 15 deaf children of deaf parents (i.e., deaf-deaf children). Only participants with two deaf or two hearing parents were included in the analyses. Of the 15 deaf-deaf children, 8 were known to have been raised with sign language only. In the case of 6 other deaf-deaf children, both signs and spoken language were used in the home. And for 1 deaf-deaf child, unfortunately, no information was available on the language used in the home. When the deaf-hearing and deaf-deaf groups were compared with respect to gender, age, hearing loss, age of onset of hearing loss, IQ, ethnicity, and school type, no significant differences for their reading comprehension ($t(440) = -.40$, $p > .10$) or word identification were found ($t(479) = .51$, $p > .10$).

Discussion

The results of the present study show the reading comprehension of deaf students in the Netherlands to be poor when compared to that of their hearing peers. Although the participants studied here had seven years of reading education on average, their mean reading scores corresponded to the first grade level for hearing children. The reading comprehension scores were found to increase with grade and no leveling off was observed. Some 19% of the deaf participants read above the third grade level, and 4% of the deaf students read at the level matching their instructional age. Nevertheless, only 50% of the deaf participants read above the first grade level and, in secondary education, the mean reading comprehension score for the deaf students was only at the second grade level. Factors found to determine whether deaf students read above or below the third grade level were age, type of current education, ethnicity, and IQ.

The word identification of the deaf participants studied here was much better than their reading comprehension. Although some small differences were found to occur between the word identification of the deaf versus hearing participants, both the deaf and hearing participants studied here scored at a fifth grade level on average.

The results of the present study only partly correspond to the results of other studies in the US and the UK. The deaf students in the Netherlands produce lower reading comprehension scores on average than the deaf students in the US and the UK (Allen, 1986; Conrad, 1979; Holt, 1993; Holt et al., 1996).

Unfortunately, a proper comparison of the reading comprehension results from the different studies is hindered by a number of factors. Different reading comprehension tests have been used in the various studies. Moreover, it is not clear whether a given grade level actually refers to the same reading comprehension level across different countries. Only the recent PIRLS study by Mullis, Martin, Gonzalez, and Kennedy (2003) has shown the reading comprehension of Dutch fourth graders to closely resemble that of their US peers.

The deaf participants studied here showed the same level of word identification on average as the hearing participants. These results are similar to those of Burden and Campbell (1994), who found 14-year-old deaf students to identify words just as accurately and quickly as their hearing peers. In college students, Fischler (1985) also found no differences between the word recognition of deaf versus hearing graduate students. In other research, however, both Harris and Beech (1998) and Merrills et al. (1994) found the word recognition of 4- to 6- and 11- to 15-year-old deaf students to be lower than that of hearing students.

Once again, a thorough comparison of the relevant findings is restricted by a number of factors. The study by Harris and Beech (1998), for example, involved younger children than the present study. This means that the children studied by Harris and Beech might not differ from their hearing peers when older. Differences in the tasks used to measure word identification could also lead to different results. Just as Merrills et al. (1994) and Fischler (1985), we used a lexical decision task while Harris and Beech (1998) used a picture-word matching task. Deciding whether a letter string represents a real word or not may require very different skills than matching words to pictures. Language differences may also account for some of the differences observed between the present study and American or British studies. Unlike English orthography, Dutch orthography encodes phonology in a rather transparent manner (de Jong & van der Leij, 1999; Reitsma & Verhoeven, 1990). This means that the reading of most Dutch words simply involves the decoding of grapheme-phoneme correspondences. And the development of phonological awareness and word decoding skill is likely to occur faster in a language with a transparent orthography than in a language with a deep orthography (de Jong & van der Leij, 1999; Müller & Brady, 2001; Seymour, Aro, & Erskine, 2003). In other words, the more transparent orthography associated with the Dutch language may make word identification easier for not only hearing children but also deaf children.

An exploratory comparison of the word identification and reading comprehension of the deaf children of deaf versus hearing parents revealed no significant differences. Early exposure to language did not appear to help the deaf-deaf participants acquire reading skill. It is important to note, however, that only 8 of the 15 deaf-deaf students were raised with sign language only. The other participants were raised with a combination of signs and spoken language. Along these lines, a significantly higher percentage of those deaf participants reading above a third grade level were found to have had spoken language input at home and at school when compared to those deaf subjects reading below a third grade level. Moreover, those participants whose home language consisted of spoken language only performed significantly better on reading comprehension and word identification than those participants whose home language consisted of sign language only. Taken together, these results do not correspond to the results of studies showing early access to sign language to be a good predictor of later reading comprehension (Padden & Ramsey, 1998; Singleton et al., 1998) or studies showing early access and not the form of the language to be of importance (Harris & Beech, 1998; Luetke-Stahlman, in Musselman, 2000).

According to the simple view of reading, one possible explanation for deaf children's reading comprehension problems may be word identification problems. However, the present study shows the word identification of deaf children to not differ sufficiently from the word identification of hearing children to explain the observed differences in reading comprehension. As Merrills et al. (1994) concluded in their study, word identification may explain some but certainly not all of the reading comprehension difficulties encountered by deaf children. When deaf children's word identification is in keeping with their instructional age, moreover, their reading comprehension may still lag behind and thus be lower than that of their hearing peers. In keeping with the simple view of reading, this implies that the explanation for deaf children's low reading comprehension must lie in not their word identification but in their linguistic comprehension.

Hoover and Gough (1990) defined linguistic comprehension as "the ability to take lexical information and derive sentence interpretations" (p.131). We hypothesize that deaf children's lack of access to language may cause difficulties with the learning of word meanings that tend to be acquired via linguistic explanation (Wauters, Tellings, van Bon, & van Haaften, 2003). More specifically, the reading of texts with many words whose meanings have to be acquired via linguistic explanation may be quite difficult and therefore lead to comprehension problems. In a previous study (Wauters et al., 2003), school reading texts were indeed found to contain a higher percentage of word meanings that are probably learned via linguistic information than word meanings that are probably learned via perceptual information – starting as early as Grade 3. Difficulties with the learning of word meanings via language may therefore produce difficulties with the understanding of such texts although further research is needed to investigate just whether and how the aforementioned difference in word meanings affects the text comprehension of both hearing and deaf students.

The results of the present study show the reading comprehension of deaf students in the Netherlands to be lower than expected on the basis of their word identification. In other words, the reading comprehension problems of deaf children appear to be the result of other, linguistic-comprehension factors and future research should further explore the exact nature of these factors.

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Appendix A

First grade reading test sample (translated)

1. Eric and Tom live in a beautiful house.
2. Downstairs are a hallway, a kitchen, and a living room.
3. Upstairs are three bedrooms and a bathroom.
4. Up one floor is the attic.
5. When the weather is bad, they sometimes play there.
6. Behind the house is a shed.
7. That is where the bikes are.
8. Every morning, Eric's mother gets his bike out of the shed.

Where do you find a hallway? (sentence 2)
- o in a room
- o behind a house
- o in a shed
- o when entering a house

Read sentence 8. Which of the below is correct?
- o Every morning, Eric's mother puts his bike outside the shed.
- o Every morning, Eric puts his mother's bike outside the shed.
- o Every morning, Eric gets his mother's bike out of the shed.
- o Every morning, Eric puts his mother's bike in the shed.

Where do Eric and Tom sometimes play? (sentence 5)
- o in the kitchen
- o in the hallway
- o in the shed
- o in the attic

Where do Eric and Tom live?
- o in a flat
- o in a very high house
- o in a normal house
- o in a very low house

What is the story about?
- o about a beautiful house
- o about Eric and Tom's house
- o about a house with an attic
- o about a house with a shed

APPENDIX B

Sixth grade reading test sample (translated)

The telephone has now exists for about a hundred years. Viewed historically, this is actually a very short period of time. Across those 100 years, though, the telephone has become very, very popular. When you say, “I am going to give Jan a call” these days, it is something very normal.

The telephone made by Bell looked very different from the current ones. However, the principle is still the same: two people are able to talk to each other by means of a microphone, a wire transmitting electrical signals, and a receiver. That is, the spoken word is converted into electrical signals and then the other way around.

Bell’s first telephone system consisted of two telephones connected by a wire. When using more than two telephones, a switchboard is needed. That is, the wires from the different telephones must all come together somewhere. When two users want to talk to each other, the wires for those two telephones can then be connected to each other via such a switchboard.

The first switchboard in the world had only 21 telephones connected to it! This number quickly increased, however. Many cities in the world acquired switchboards. And connections between cities were set up quickly as well. For those having to operate the switchboards, things became very complicated. As a consequence, people got “wrongly connected” more often and found themselves speaking to someone other than the person they wanted to speak to!

That is why, about 50 years ago, they began to automate such switching using a computer. The telephones were given a dial. When you dialed a number, you were connected to another telephone directly without the intervention of a switchboard operator.

Such automated calling was only possible with people in your own town. Later it became possible with people in other cities as well. Nowadays you can even call many cities abroad.

What did Bell find out?

a. that telephones could be connected
b. that the telephone would become very popular
c. that there was a need for telephone exchanges
d. that words could be converted into electric signals

Someone ended up talking to the wrong person because…

a. they were wrongly connected
b. automated calling failed
c. people lived too far away from each other
d. the telephone wires broke

To automate telephone exchanges…

a. the operators got new headphones
b. the telephones got dials
c. the telephones got new wires
d. the switchboards got new buildings

MODE OF ACQUISITION OF WORD MEANINGS: THE VIABILITY OF A THEORETICAL CONSTRUCT[8]

Abstract

This article examines the reliability and validity of the construct *mode of acquisition* (MOA). The MOA of a word denotes the way in which the word's meaning is learned. A word's meaning can be acquired perceptually, linguistically or by some combination of both. In Experiment 1, 26 student volunteers from third year special education courses rated 566 words, taken from reading texts in elementary school, on MOA. Our findings show that MOA ratings gradually change over grades, shifting from mainly perceptually acquired word meanings in Grade 1 texts to mainly linguistically acquired concepts in Grade 6 texts. In Experiment 2, 34 educational professionals completed a list on MOA, concreteness, or imageability. Judgments on MOA proved to be different from both concreteness and imageability. We suggest that the increasingly linguistic character of word meanings contributes to explaining some of the reading difficulties of deaf children.

Introduction

Whereas many word characteristics have been investigated extensively, such as word familiarity, age of acquisition, concreteness, and imageability (Altaribba, Bauer, & Benvenuto, 1999; Campos, 1995; Gilhooly & Logie, 1980; Paivio, Yuille, & Madigan, 1968; Spreen & Schulz, 1966; Van der Goten, De Vooght, & Kemps, 1999; Van Loon-Vervoorn, 1985, 1989), mode of acquisition (MOA) has been neglected. Mode of acquisition refers to the type of information – perceptual, linguistic, or some combination of both – used in acquiring the meaning of a word. This study investigates the reliability and validity of determining mode of acquisition.

As Bloom (2000) defines it "to know the meaning of a word is to have

1. a certain mental representation or concept
2. that is associated with a certain form" (p. 17).

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[8] Reference: Wauters, L. N., Tellings, A. E. J. M., van Bon, W. H. J., & van Haaften, A. W. (2003). Mode of Acquisition of word meanings: the viability of a theoretical construct. *Applied Psycholinguistics, 24*, 385-406.

This implies that in learning the meaning of a word a child may already have the concept and only needs to attach the word to it. Children can have many concepts without knowing which words correspond to them (Bloom, 2000). However, Bloom's definition of word meaning implies that a child may also learn a word and its concept simultaneously.

Mode of acquisition designates the way in which children (or adults) learn the meaning of words. Roughly, the meaning of a word can be acquired through perception, through linguistic information, or both. For some words, MOA is determined by the nature of their referents. The meaning of color words, for example, will be learned almost entirely through perception, if only because no exclusively verbal description of colors can be given. The meaning of a word like *grammar* will not be learned through perception, because language is indispensable to explain what grammar is. For other words, MOA wholly or partially depends on contingent factors such as time, place, culture, social economic status (SES), or even, in the case of deaf children, handicap. For a word like *tundra*, MOA depends on the environment in which the word is learned. Children who live near a tundra will probably learn the meaning of *tundra* through perceptual information. However, in countries like the Netherlands, where tundras do not exist, the word will be learned linguistically or maybe through a combination of perceptual (through pictures) and linguistic information. Children of higher SES might learn the meaning of *golf club* through perception, while children of lower SES may have to learn its meaning through linguistic information. *Coal-scuttle* is a word of which children who grow up in the 21st century learn the meaning through linguistic information. When coal-scuttles were still in use, children acquired the meaning of the word through perception. A child whose father is a carpenter will learn the meaning of most words that refer to carpentry tools through perceptual information while other children will have to learn these meanings through linguistic information. Thus, generally MOA is a context-relative rather than an absolute word characteristic. As opposed to characteristics like concreteness and imageability, MOA is context dependent.

Several aspects of how children acquire concepts and word meanings have been studied. Similar to, but somewhat different from MOA is the distinction made by Schreuder, Flores d'Arcais, and Glazenborg (1984, see also Flores d'Arcais, Schreuder, &

Glazenborg, 1985) with respect to components of the semantic information connected to a word. They draw a distinction between perceptually based information and conceptual or knowledge-based information underlying a word's meaning. "Perceptually based information consists of properties based on attributes which are directly present in our perceptual experience with the referents of the word, such as form or color" (Flores d'Arcais et al., 1985, p. 40). Conceptual or knowledge-based information, according to Schreuder et al., consists of features that are not physically given but are inferred from properties such as the function of the objects to which a concept refers or the relationship to other objects. Perceptual properties are acquired earlier than conceptual properties and they are likely to be deeply rooted in our semantic system. In their study, Schreuder et al. (1984) found that both perceptually based and conceptually based information contribute to semantic priming, independent of each other.

Madole and Oakes (1999) concentrate on what they call *the perceptual-conceptual debate*. Perceptual and conceptual here refer to different modes of categorization in infants. Perceptual categorization is based on features of objects that can be derived from visual inspection of an object, like shape, structure, and color. Conceptual categorization is making inductive inferences based on shared taxonomy, for instance, that greyhounds and poodles both are dogs despite their different looks.

Schreuder et al.'s (1984) notion of perceptual information is similar to ours, but their conceptual or knowledge-based information is dissimilar to our linguistic information, if we assume that knowledge and concepts as such can contain, or can be based on, both perceptual and linguistic components. When describing knowledge-based information, Schreuder and his colleagues refer to both linguistic components and features "inferred from properties such as the function of the referents, the relations to other objects, and so forth". The same is true for Madole and Oakes (1999). Their perceptual categorization is similar to our notion of perception, but when describing conceptual categorization or conceptual knowledge they refer solely to inductive inferences. Both Madole and Oakes (1999) and Schreuder et al. (1984) include the inferences children make about word meanings in their conceptual or knowledge-based component. Schreuder et al. describe their distinction as concerning types of information present in the mental lexicon and thus including inferences made by the child. Madole and Oakes describe their distinction in different terms. They mention types of information, features of objects, abilities of the child, and knowledge present in the child's mind, respectively. They connect the latter with inferences just like Schreuder et al. do. Because our distinction concerns information coming from outside (perceptual or linguistic information) instead of knowledge of information in the mental lexicon, inferences fall outside the scope of our distinction.

Markman (1999) draws attention to the role of linguistic information in word learning as one of the diverse sources of information children integrate when acquiring the meaning of words. She furthermore suggests that parents adapt the input to the linguistic development of their children. Weizman and Snow (2001) investigated the relation between lexical input and vocabulary acquisition and found that early exposure to sophisticated vocabulary (defined as vocabulary beyond the 3000 most common words in English) had a positive influence on vocabulary acquisition. This relation was even stronger when mothers also explained the meaning of the words to the child and made sure that the child understood the information, which demonstrates that linguistic information facilitates the acquisition of the meaning of words. Based on their research findings, Weizman and Snow conclude that "for the improvement of children's vocabulary, there can be no substitute for ample cumulative experience with lexically rich, naturally occurring conversations early in life" (p. 278). Chall (1987) also states that direct verbal instruction is essential in learning the meaning of words.

The present study examines the viability of MOA as a theoretical construct. First, we examine the reliability of measuring MOA by determining the agreement between participants in their judgment of the way in which word meanings are acquired.

Second, the validity of MOA is tested by investigating the MOA of words used in reading texts for the successive grades of elementary school. MOA would be shown to be valid, at least for the purpose of characterizing texts, if reading texts could indeed be differentiated with respect to the MOA of the words used. According to the *Simple View of Reading* (Hoover & Gough, 1990), text comprehension is the product of decoding skills and listening comprehension. A lack in decoding skill leads to difficulties with texts when the orthographic complexity increases. A lack in listening comprehension makes texts that demand a high level of language proficiency too difficult. Text factors determining the required level of language proficiency are the number of infrequent words, the sentence length, and the sentence complexity. Texts for the successive grades of elementary school will be constructed with these factors in mind. If MOA might be an additional factor that is taken into account in constructing reading texts, this should be reflected in the choice of words used for the different grades. We assume that reading texts for the lower grades of elementary school consist mostly of perceptually acquired word meanings, while the use of words that require verbal explaining of their meanings is postponed to the higher grades. This different selection of words for texts for the successive grades may influence comprehension. In addition, we investigate how MOA is related to concreteness and imageability.

Our main motivation for investigating the construct of MOA is its potential relevance for explaining deaf children's text comprehension development. After third grade, deaf children's text comprehension skills seem to reach an upper limit (King & Quigley, 1985). The mean grade equivalent for reading comprehension of deaf children (aged between 15;6 and 16;6 years) is 3.5 (Furth, 1966; Quigley & Paul, 1984). Allen (1986) found that, as a group, 18-year old deaf students did not even reach the third grade level of reading comprehension. Our hypothesis is that the nature of concepts in reading texts above third grade level might be an explanation for these text comprehension problems of deaf students.

We suppose that the early, perception-based conceptual development of deaf children will generally follow the same path as that of hearing children, except for typically aural concepts such as *ring* and *whisper*, which deaf children have to learn through linguistic information. According to Kuczaj (1999), "the unique characteristic of word meaning development is that much of it occurs after other aspects of language development are more or less completed" (p. 134). This would place deaf children of hearing parents in a disadvantaged position, because they receive only a reduced amount of verbal information through lip-reading and the input of sign language is delayed till a later age (because parents only learn this language at a later point in the child's development). Because of this limited access to language, acquiring word meanings through linguistic information will be more difficult for deaf children of hearing parents than it is for hearing children. For deaf children, reading texts for the higher grades, containing a relatively high proportion of words of which the meaning has to be acquired through linguistic information, will be difficult to understand. A leveling off in text comprehension after third grade level may be explained by MOA if, from this point, reading texts contain a higher proportion of linguistically acquired word meanings.

In Experiment 1 we examine the reliability and this aspect of the validity (text differentiating ability) of MOA. Next, in order to endorse our findings of Experiment 1, Experiment 2 replicates this experiment with different participants and also studies whether MOA can be differentiated from the word characteristics concreteness and imageability.

EXPERIMENT 1

In Experiment 1 we investigated the mode of acquisition of the meaning of words taken from reading texts used in the different grades of elementary school. This experiment had a dual purpose. We wanted to find out, first, whether MOA can be reliably determined and, second, whether reading texts for the successive grades of elementary school can be differentiated with respect to MOA. In this experiment MOA is defined by a five-point rating scale, from 1, which indicates word meaning acquisition through purely perceptual information, to 5, which is acquisition through linguistic information only. We expected average MOA ratings to rise over grades. This would imply that texts for the lower grades contain more word meanings acquired mainly through perception (word meanings with an MOA rating lower than 3) and texts for the higher grades contain more word meanings acquired predominantly through linguistic information (word meanings with an MOA rating higher than 3).

This rise in MOA can be gradual. In that case, reading problems in general could arise when the number of linguistically acquired meanings in the text starts diverging too much from the number of linguistically acquired word meanings in the reader’s lexicon. The specific reading problems of the majority of deaf children, getting stuck at third grade level, would be explained in this way when the number of linguistically acquired word meanings in texts beyond third grade exceeds the number of linguistically acquired word meanings in the lexicon of these deaf children to such a degree that text comprehension is no longer possible for them. We call this the *gradual increase hypothesis*.

It is also possible that the curve of MOA initially increases gradually and shows a sudden increase after third grade. In that case, deaf children give evidence of reading problems after third grade because this sudden huge number of linguistically acquired word meanings in texts is insurmountable for them. We will call the assumption of such a sudden increase after third grade the *accelerated increase hypothesis*. Of course, such acceleration would demand extra text comprehension efforts of nondeaf fourth grade readers as well.

A sudden change in word content after third grade can be expected, because reading instruction in Grades 1 to 3 focuses on decoding skills and uses simple reading texts to ensure that most children can understand the content (Van Bekkum, 1996). Therefore, we assume that reading texts for the first three grades contain word meanings that are available even to children with poor language proficiency. Only in the higher grades does the emphasis in reading instruction shift toward comprehension (Cain, 1996; Droop, 1999; Reitsma & Verhoeven, 1990). According to Reitsma and Verhoeven, children in the lower grades only read short texts of low information content. In the higher grades, children start reading longer texts that are mainly written or selected for the purpose of reading comprehension instruction or for providing information. From fourth grade onward, reading texts will contain word meanings that are available to the average fourth grade child. For these texts, children may need certain knowledge that was not required in the lower grades (Snow, Burns, & Griffin, 1998). According to Chall (1987), a shift takes place at about fourth grade, from children's struggle with word recognition to a struggle with word meaning, with the reading materials containing a high number of unfamiliar words.

For the purpose of this study, words were taken from reading texts for the successive grades in elementary school in order to examine whether reading texts in the successive grades differ with respect to the MOA of the words used. The words from the reading texts were rated on MOA by adults, as is done in research to estimate, for example, age of acquisition, imageability, and concreteness (Carroll & White, 1973; Gilhooly & Logie, 1980; Van Hell, 1998). Gilhooly and Gilhooly (1980) have shown that adult ratings can be used validly for such purposes. They asked both adults and children to rate words on age of acquisition. Ratings of the adult participants were compared to age norms in a standardized vocabulary test. Results showed high correlations between adult ratings and age norms as well as between adult ratings and child ratings.

Method

Participants

Participants were 26 student volunteers (25 female, 1 male) enrolled in third year courses in Special Education at the University of Nijmegen, the Netherlands. Participants were paid for taking part.

Materials

Words were taken from programs used for teaching reading comprehension in elementary school. First, we investigated which programs for reading comprehension instruction are used most frequently in elementary schools. An inventory in Nijmegen showed that three programs for reading comprehension are being used very frequently in Grades 2 to 6. These three programs were selected for our research. A program that is often used in deaf education was added. From each of these four programs and for each grade, three reading texts were selected at random. Because different programs for teaching reading are used in Grade 1, eleven texts were randomly selected for this grade from two frequently used decoding training programs to approximate the total number of words in the 12 texts used for each of the other grades. From this text sample we extracted all nouns, verbs, and adjectives, leading to a total of 9232 tokens. Out of this total, random selections were drawn of 160 tokens per grade, which resulted in samples of about 90 types for each grade. If the same word appeared in two different grades, it was categorized as occurring in the lower of the two grades. For homonyms, the intended meaning was given in parentheses. The result of this selection procedure was a word pool of 566 lemmas in total (see Table 1 for detailed information). These 566 words were printed in random order (different for each participant), 22 to a page, except for the last page, which contained 16 words. A five-point rating scale followed each word, with 1 indicating acquisition through perception and 5 indicating acquisition through linguistic information. The 26 pages were assembled into a booklet, of which the first three pages contained the instructions.

Table 1. Distribution of words over grades.

Grade	Nouns	Verbs	Adjectives	Total	Length (in letters)
1	52	39	16	107	3 - 9
2	50	22	15	87	3 - 15
3	42	29	18	89	3 - 14
4	54	26	19	99	3 - 14
5	46	24	19	89	3 - 14
6	64	24	7	95	3 - 14

Procedure

Each participant received a booklet. The lists were completed individually. Time needed for completion was reported to range from 30 to 75 minutes. The following is the most relevant part of the instructions (originally in Dutch):

> "How do children learn the meaning of words? How does a young child learn that the word *ball* refers to a round, bouncing thing? Children can learn this in three ways.
>
> A. The child learns that *ball* refers to the round thing because every time he hears the word *ball*, he sees a real ball or sees a picture of a ball in a book. Through all these perceptual experiences with a ball every time the word *ball* is heard, the child learns what is meant by *ball*. The meaning is learned *through experience*.
>
> B. A word like *century* can only be learned *through language*. A child can learn the meaning because someone explains it to him or because he derives the meaning from what he heard or read about the word *century*. The child acquires the meaning of the word *through language*.
>
> C. Of course children also learn meanings of words through a *combination of A and B*. An example of this is when a mother shows her child a picture of a

recreational vehicle (experience) and at the same time tells the child that they are going on a holiday with it (language).

We ask you how you think children learn the meaning of the words in this list:

1. through experience
2. mostly through experience, but also a little through language
3. about as much through experience as through language
4. mostly through language, but also a little through experience
5. through language

Each word is followed by a 5-point-scale. Please rate every word on this scale. Use the whole range of the scale."

Results

High correlations (mean $r = .60$, all $p < .01$) were found between participants, which indicates that they agreed in their MOA ratings. In a principal axis factor analysis with the participants as variables and the words as cases, two factors with Eigenvalues greater than 1 were extracted. The largest part of variance in ratings was explained by one common factor. The first factor explained 56% of the variance; the second only 4%. Apart from a few exceptions, factor loadings of the different raters on the first factor are high (mean = .74), which indicates that for almost all raters the judging is determined by this common factor.

Another way to index inter-rater agreement is by means of a two-way random intraclass correlation (ICC) coefficient (McGraw & Wong, 1996). The result, ICC = .97, indicates a high agreement of the rating patterns of the different participants. As a first result we may conclude that the participants agreed in their interpretation of the instruction and their judgments about the words.

Our second aim was to see if we could find a change in MOA ratings of words used in reading texts in elementary school. The mean MOA rating was calculated for every word in the sample. We will take this mean rating as a measure of the MOA of a word. Table 2 shows the words with the lowest and the words with the highest MOA ratings. The words with the lowest ratings are *brood* [bread], *boom* [tree], and *neus* [nose]. The meanings of these words are judged to be learned almost exclusively through perceptual information. This is plausible, because these words refer to objects that can be experienced through our senses and that usually are present in the environment of the young child. The words with the highest ratings are words like *tijdperk* [era], *verdrag* [pact], and *kolonist* [colonist]. The meanings of these words pertain to affairs that cannot be easily acquired through perceptual information. The plausibility of these results is an argument in favor of the MOA estimation.

Table 2. Words with lowest and highest mean MOA ratings.

Words with lowest ratings	MOA	Words with highest ratings	MOA
brood (bread)	1.04	onderduiken (go into hiding)	4.62
boom (tree)	1.08	ras (race, people)	4.62
neus (nose)	1.08	middel (means)	4.65
pop (doll)	1.08	noordpool (north pole)	4.69
beer (bear, teddy bear)	1.12	balsahout (balsa wood)	4.73
deur (door)	1.12	criminaliteit (criminality)	4.73
mond (mouth)	1.12	dienst (duty)	4.73
bed (bed)	1.15	opoffering (sacrifice, n.)	4.73
hand (hand)	1.19	opgewassen tegen (be a match for someone)	4.73
oog (eye)	1.20	slavin (female slave)	4.76
kat (cat)	1.20	Oostkust (east coast)	4.77
arm (arm)	1.23	oogverblindend (dazzling)	4.81
koek (cookie)	1.23	buizerdachtig (buzzardly)	4.85
mam (mom)	1.23	cultuur (culture)	4.85
tafel (table)	1.23	orkaankracht (hurricane force)	4.85
vogel (bird)	1.23	werkvergunning (work permit)	4.85
water (water)	1.23	kolonist (colonist)	4.92
zand (sand)	1.23	verdrag (pact, treaty)	4.92
bloem (flower)	1.27	loodje (het loodje leggen, get the short end of the stick)	4.96
raam (window)	1.27	tijdperk (era)	4.96

A one-way analysis of variance (ANOVA)[9] with words as cases, grade as a between-cases-factor, and MOA as the dependent variable showed a significant overall effect of grade ($F(5,560) = 31.19$, $p < .01$). Figure 1 shows that the mean MOA rating increases with grade. A regression analysis with grade as the independent variable and the ratings as the dependent variable showed the linear relationship of MOA and grade to be significant ($F(1, 564) = 143.9$, $p < .01$). We also found a positive quadratic relation between MOA and grade ($F(2,563) = 74.5$, $p < .01$), indicating that the increment of MOA increases with grade. As expected, the MOA ratings increase with grade, which means that the meaning of words used in reading texts for the lower grades are rated as being learned more perceptually whereas the meaning of words in higher grades are rated as being learned more linguistically.

Our explanation of deaf children's reading comprehension difficulties would be supported by a sudden increase of MOA ratings after Grade 3. Examination of the curve in Figure 1 does not reveal such acceleration after Grade 3. A necessary condition for an accelerated increase after third grade is that the pooled scores of words in Grades 1, 2, and 3 differ significantly from the pooled scores of words in Grades 4, 5, and 6. An ANOVA shows this difference to be significant indeed ($F(1, 564) = 80.6$, $p < .01$). As a second step in testing this explanation, a linear regression analysis was performed on the mean MOA ratings of the words used in Grades 1, 2, and 3. Using the resulting regression coefficients, the expected value of the mean MOA rating in Grade 4 (mean = 3.03) was calculated. The mean of the observed values (mean = 3.05) did not significantly differ from this expected value ($t(98) = .29$, $p > .5$). Following the same procedure, no difference was found between the observed and expected value for Grade 5. However, a significant difference was found between the observed and expected value for Grade 6 ($t(94) = 4{,}99$, $p < .001$), with the observed value being higher. These results imply a gradual increase of MOA over grades with a sudden increase after Grade 5.

The overall results of this experiment do not support the accelerated increase hypothesis. The MOA curve does not show such acceleration after Grade 3. Based on the

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[9] It should be noticed that in this and other analyses of variance we have chosen to use the conservative F_2-design for analyzing our data (Clark, 1973).

results, we cannot speak of a sudden increase of MOA after third grade. Such an increase seems to occur only after Grade 5. Nevertheless, a gradual increase hypothesis might still explain deaf children's text comprehension problems.

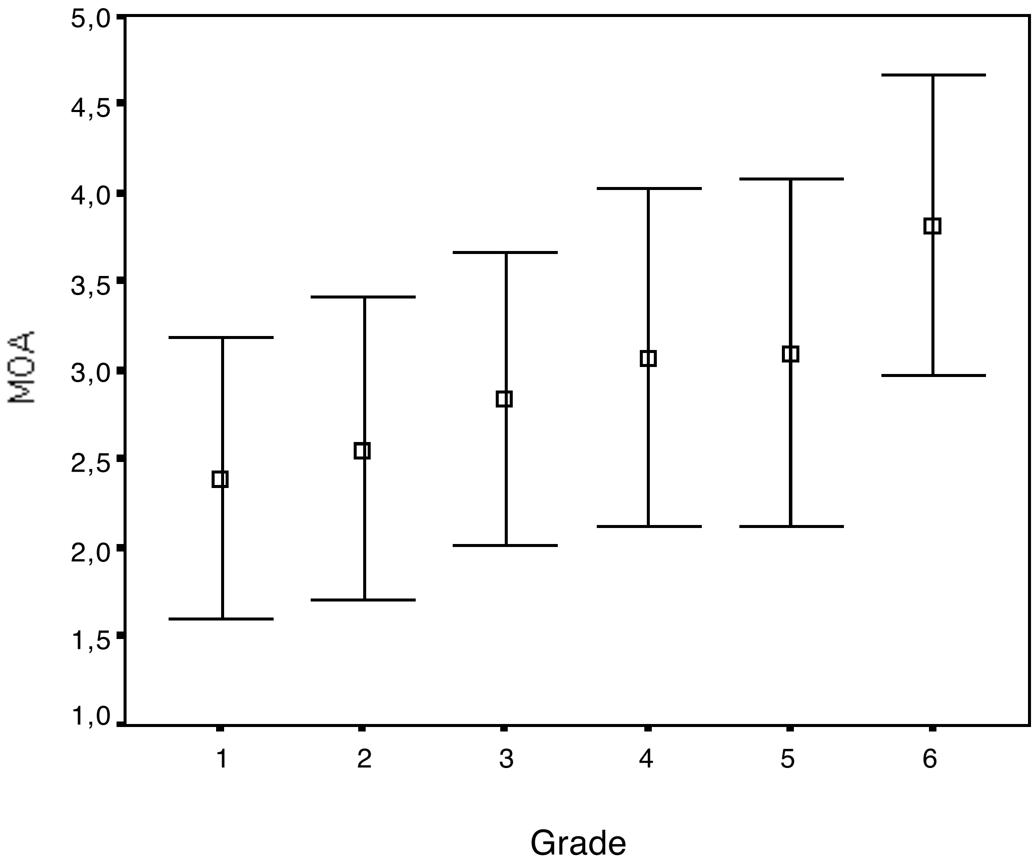

Figure 1. *The mean MOA and 1 SD range for the words sampled for each grade.*

Figure 2 depicts the way in which reading texts are composed with respect to MOA. In Grades 1 and 2, reading texts appear to consist mostly of words of which the meaning is learned mainly through perceptual information. Reading texts in Grade 3 mainly contain word meanings in the middle of the MOA range, which are learned through perceptual as well as linguistic information. Reading texts in Grades 4 and 5 consist of word meanings acquired through perceptual and linguistic information; in addition, more word meanings are learned through linguistic information only. Texts in Grade 6 mainly consist of words learned through linguistic information.

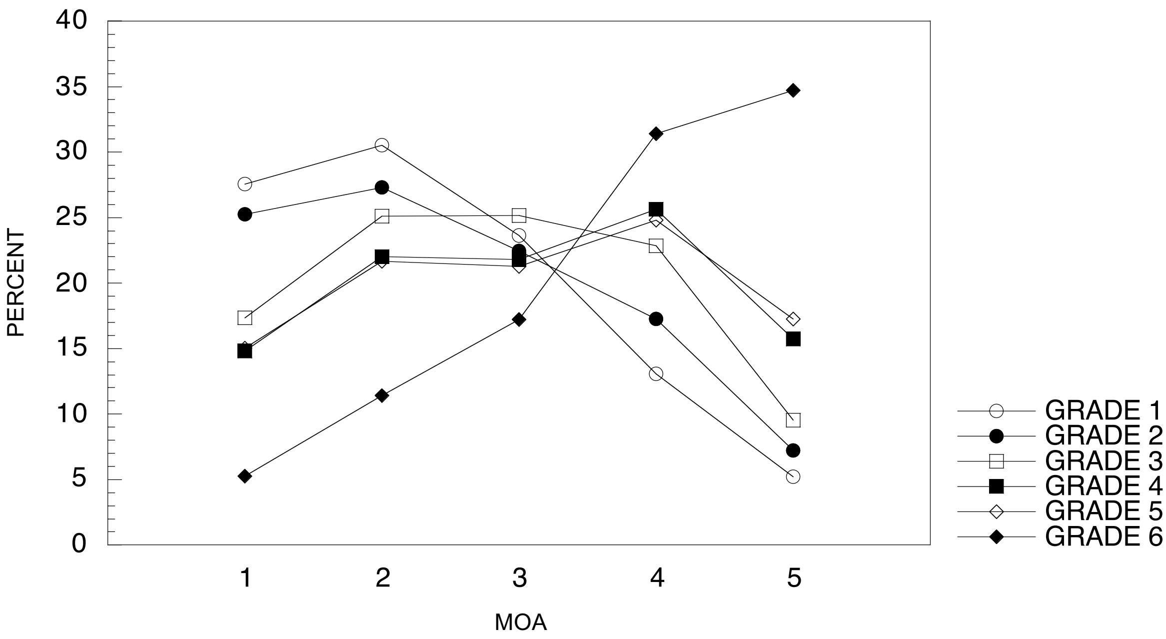

Figure 2. Percentages of MOA ratings for each grade.

Discussion

This experiment concentrated on whether MOA can be measured reliably and whether reading texts in the successive grades of elementary school differ in the MOA of the words used. Factor analysis and intraclass correlation show that MOA can be reliably determined by means of adult ratings on a 5-point scale.

Further results show an increase in the mean MOA ratings with grade. The mean MOA of word meanings in Grade 1 is low, indicating acquisition through perceptual information. In Grade 6, the mean MOA-rating is high, indicating that linguistic information is considered to have played a major role in the acquisition of word meanings that occur in reading texts in this grade. Apart from an increase in the mean MOA ratings, differences are found in the distribution of words over different categories of the MOA scale. As Figure 2 shows, many words that occur in reading texts in Grades 1 and 2 are judged to be learned mainly through perceptual information. The increase in the number of words learned through linguistic information starts in Grade 4 and expands in Grade 5 and especially in Grade 6. These results indicate that reading texts used in the successive grades differ in the ratio of perceptually versus linguistically acquired word meanings.

This change in the character of word meanings may explain the text comprehension difficulties some children have with texts in the higher grades.

According to the accelerated increase hypothesis about deaf children's reading comprehension, a sudden increase in the number of linguistically acquired concepts should be seen after Grade 3. However, such a sudden increase occurs only after Grade 5. These results show that the increase of MOA around Grade 3 is gradual rather than sudden, which is in accordance with the gradual increase hypothesis.

Having established that MOA can be measured reliably and is valid, at least for differentiating reading texts, it is interesting to further examine its viability by exploring its relation to the word characteristics concreteness and imageability (Gilhooly & Logie, 1980; Janssen, 1973; Paivio, Yuille, & Madigan, 1968; Spreen & Schulz, 1966; van Loon-Vervoorn, 1985). This issue is addressed in Experiment 2. Experiment 2 will also establish whether MOA ratings given by educational professionals are comparable to those given by students, participating in Experiment 1.

EXPERIMENT 2

In this experiment we examine whether professionals who work with children (like special educators, speech therapists, teachers, etc.) make the same judgment on how word meanings are learned as the students in Experiment 1. In addition, we investigate whether we can differentiate MOA from both concreteness and imageability by asking participants to judge the same set of words on either MOA, or concreteness, or imageability.

One reason for assuming that MOA is different from concreteness and imageability is that the meaning of some concrete and highly imageable words has to be acquired linguistically. Words like *balsa wood* and *comrade* are highly concrete or highly imageable, yet linguistic information is necessary to acquire their meaning.

Van Loon-Vervoorn (1985) investigated the relation between imageability and age of acquisition of words. She found that most words learned at an early age are highly imageable and most words learned later have a lower imageability. Furthermore, she argues that the meanings of early-learned words have a sensorimotor basis. As children grow older, meanings tend to be learned through language. Although Van Loon-Vervoorn establishes a high correlation between concreteness and imageability, she notices that superordinate, and therefore more abstract, words like *dog* and *tree* are more imageable than more concrete words like *Labrador* and *oak*. Words like dog and tree "are learned early and therefore have a rich sensorimotor meaning basis" (Van Loon-Vervoorn, 1985, p. 39, our translation). According to this reasoning, it is possible to learn the meaning of at least some abstract words through perceptual information.

Method

Participants

Lists were distributed at a conference on dyslexia to 60 volunteer participants. Thirty-four lists were completed and returned. Participants (25 female, 9 male) were teachers (in primary or secondary school), remedial teachers, psychologists, and educational advisors.

Materials

For this experiment we randomly selected half of the words (283) from the list used in the first experiment (see Table 3 for detailed information). These 283 words were printed in random order (different for each participant) to be rated on either MOA, or concreteness, or imageability. The lists were randomly distributed among participants.

MOA ratings were made on a 5-point scale, as in the first experiment, while concreteness and imageability ratings were made on a 7-point scale with 1 indicating low concreteness or low imageability, respectively, and 7 indicating high concreteness or high imageability, respectively. In using 7-point scales for investigating concreteness and imageability we follow other studies in this field (Altaribba et al., 1999; Gilhooly & Logie, 1980; Paivio, Yuille, & Madigan, 1968; Spreen & Schulz, 1966; Van Loon-Vervoorn, 1985).

Table 3. Distribution of words over grades in Experiment 2.

Grade	Nouns	Verbs	Adjectives	Total	Length (in letters)
1	26	20	5	51	3 - 8
2	24	11	13	48	3 - 15
3	19	8	9	36	3 - 10
4	26	13	10	49	3 - 14
5	28	13	9	50	3 - 14
6	39	7	3	49	3 - 12

Procedure

The instructions for the participants who rated words on MOA were the same as in Experiment 1. Instructions for the participants who rated words on imageability were taken from Paivio, Yuille and Madigan (1968). Instructions for the participants who rated words on concreteness were derived from Spreen and Schulz (1966).

Results

The total sample of 34 lists consisted of 10 lists on MOA, 10 on concreteness, and 14 on imageability. We begin by analyzing the data on MOA, and comparing the data from Experiment 2 (educational professionals) with those from Experiment 1 (students). A mean correlation (r) of .56 (all $p < .01$) was found between the educational professionals. In a principal axis factor analysis with professional participants as variables and words as cases, only one factor with an Eigenvalue over 1 was found. This factor explained 51% of the variance. All raters had high loadings on this factor (mean = .71). The scores of the individual words on this factor correlated highly with those on the major factor in Experiment 1 ($r = .93$, $p < .01$), which points to a strong agreement between the ratings of the two samples of judges. A two-way random intraclass correlation coefficient showed an ICC of .91 ($p < .01$), indicating high interrater agreement.

Figure 3 shows a gradual increase of MOA over grades with a sudden increase after Grade 5. A Oneway ANOVA with words as cases, grade as a between-cases-factor, and MOA as the dependent variable showed a significant difference between grades

($F(5,277) = 12,85$, $p < .01$). A regression analysis showed a significant linear relation between MOA and grade ($F(1,281) = 50.37$, $p < .01$), with higher MOA ratings in the higher grades. Regression analysis also showed a significant positive quadratic relation ($F(2,280) = 25,95$, $p < .01$).

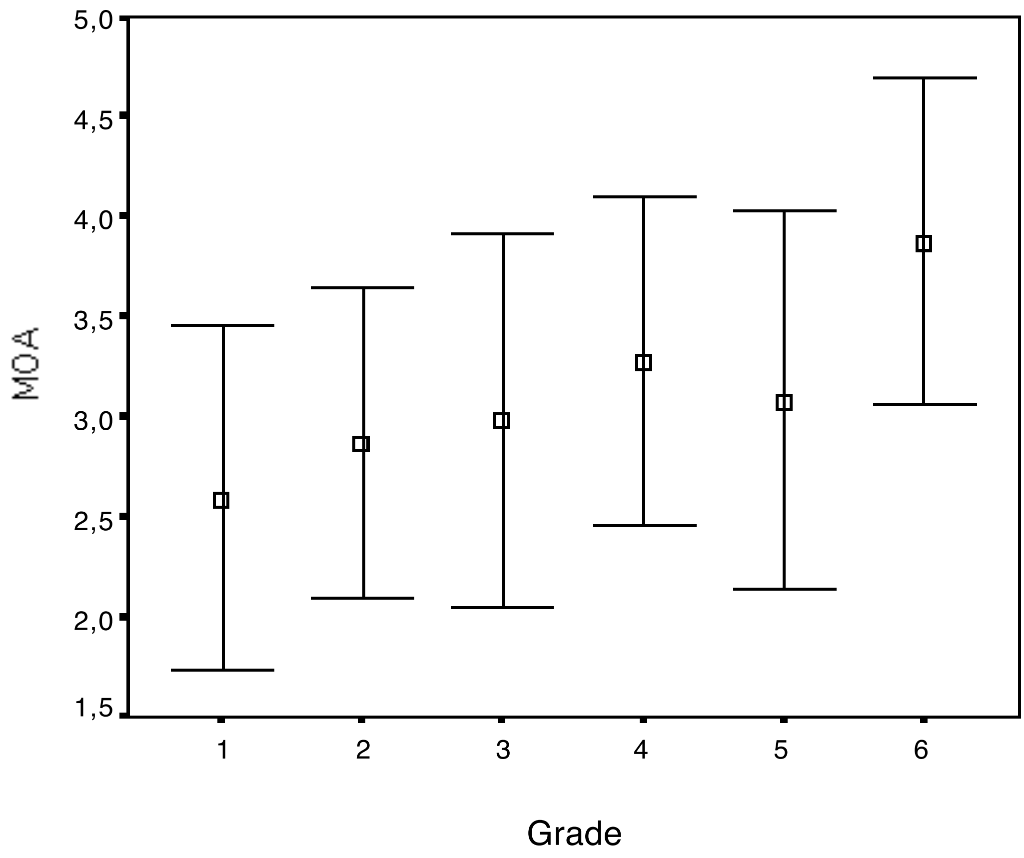

Figure 3. *The mean MOA, rated by educational professionals, and 1 SD range for the words sampled for each grade.*

An ANOVA showed that the pooled scores of words in Grades 1, 2, and 3 differ significantly from the pooled scores of words in Grades 4, 5, and 6 ($F(1,281) = 33,46$, p°$< .01$). A linear regression analysis on the mean MOA ratings of the words in Grades 1, 2, and 3 was performed to calculate the expected value of the mean MOA rating in Grade 4. The mean of the observed values in Grade 4 (mean = 3.28) did not significantly differ from the expected value (mean = 3.22) ($t(48) = .46$, $p > .5$). However, a significant difference was found between the observed and expected values for Grade 5 ($t(49) = -2.94$, $p < .01$). Here, the observed value was lower than the expected value. A significant difference was also found between the observed and expected value for Grade 6 ($t(48) = 4.32$, $p < .01$), with the observed value being higher. Again, the overall results of this experiment do not support the hypothesis of an accelerated increase after third grade, which leaves the gradual increase hypothesis as an explanation for deaf children's reading comprehension problems.

Figure 4 gives a more detailed view of the way in which MOA differs over grades. In Grades 1 to 5, most of the words fall in the middle three categories of MOA. In Grade 6 a change is noticeable, with most word meanings acquired through linguistic information. As in Experiment 1, reading texts from fourth grade onwards contain more linguistically acquired word meanings than perceptually acquired word meanings.

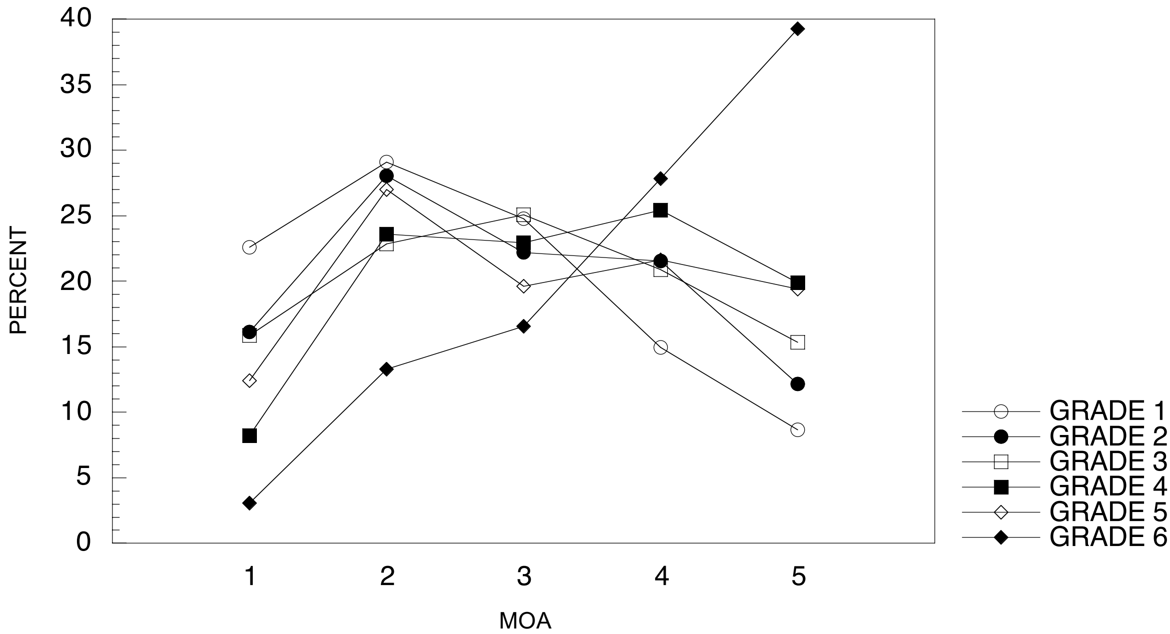

Figure 4. *Percentages of MOA ratings by educational professionals for each grade.*

Before discussing the specificity of MOA, we will discuss analyses for concreteness and imageability ratings independently. High mean correlations were found between participants, with mean $r = .65$ (all $p < .01$) for concreteness and mean $r = .62$ (all $p < .01$) for imageability. We performed principal axis factor analyses for concreteness and imageability with raters as variables and words as cases. In both analyses, only one factor with an Eigenvalue over 1 was found. For concreteness, this factor explained 61% of the variance with a mean factor loading of .78. For imageability, the factor explained 59% of the variance with a mean factor loading of .77. Two way random ICC coefficients showed a value of .94 ($p < .01$) for concreteness and .95 ($p < .01$) for imageability. These results indicate that the participants agreed in their judgments of concreteness and imageability.

Figures 5 and 6 show the distributions of ratings over the concreteness and imageability categories. They indicate that there is no clear increase of concreteness or imageability over grades. The distribution remains rather the same in the different grades. Figure 7 shows the mean ratings for concreteness, imageability, and MOA.

No significant relation was found between grade and concreteness ($F(5,277) = .55$, $p > .10$). There is no evidence of words being more concrete in lower grades and more abstract in higher grades. However, a significant relation was found between grade and imageability ($F(5,277) = 2.53$, $p < .05$). T-tests showed the mean imageability in Grade 6 to be significantly lower than in the other grades, except Grade 4.

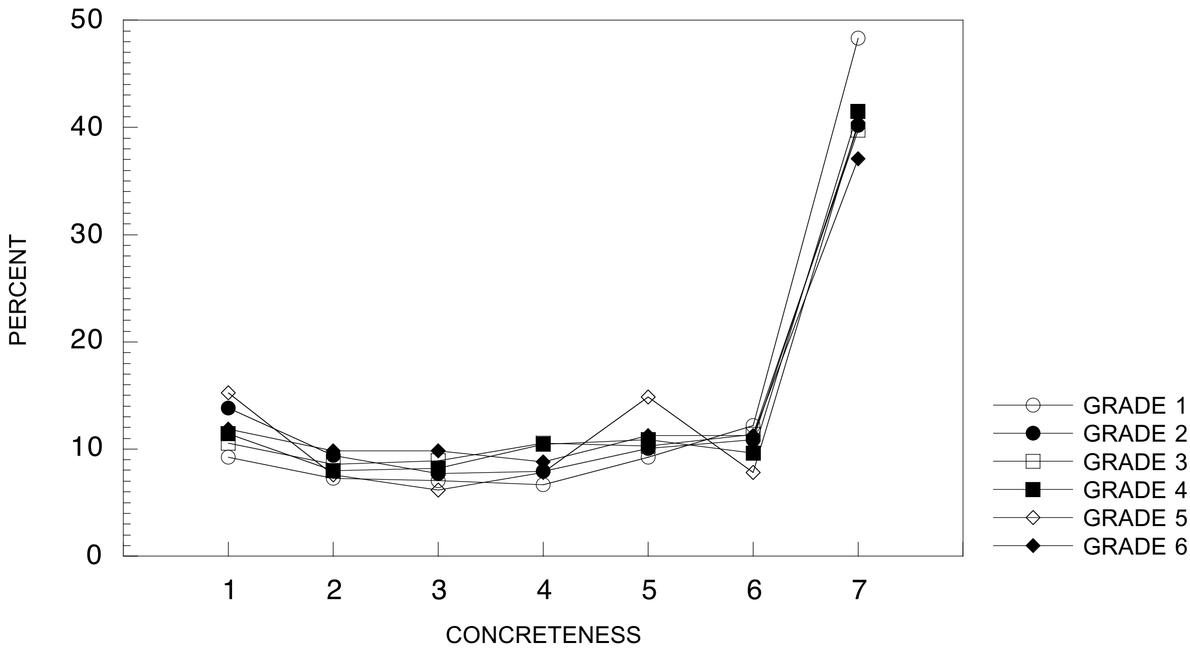

Figure 5. Concreteness ratings for each grade.

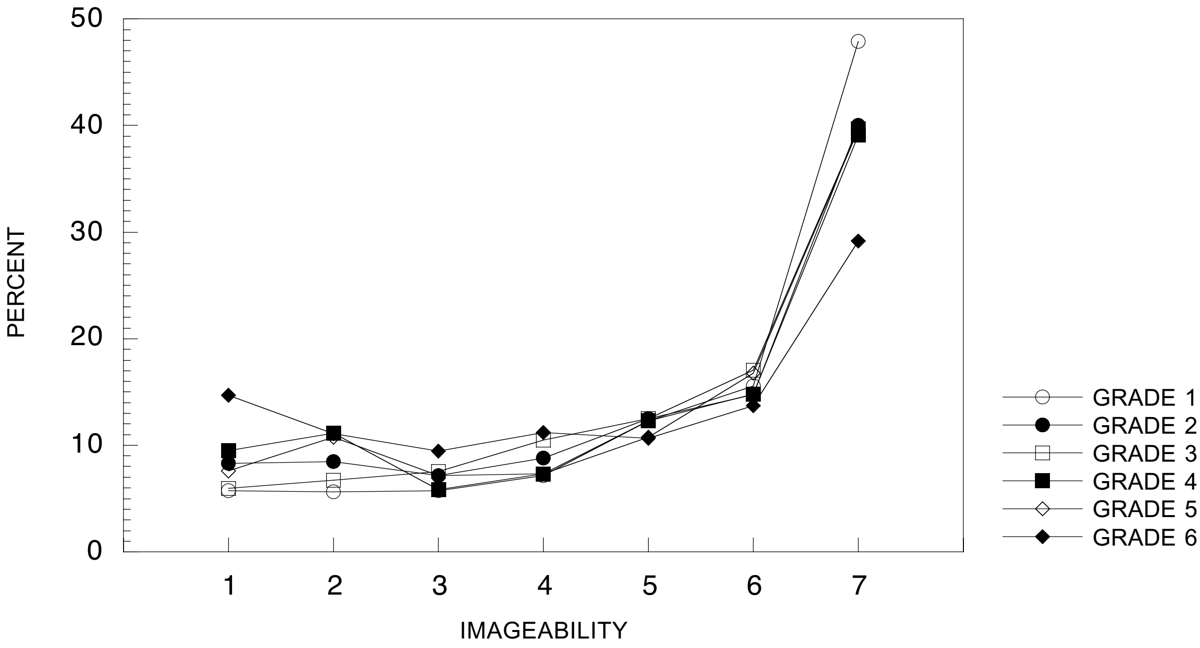

Figure 6. Imageability ratings for each grade.

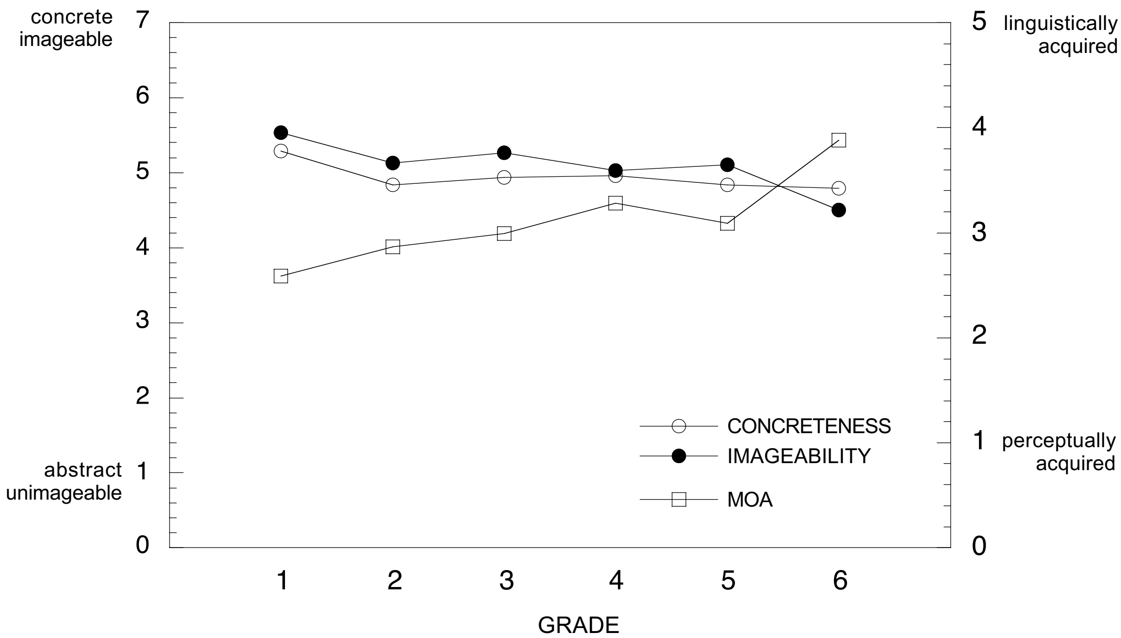

Figure 7. Mean ratings for concreteness, imageability and moa by grade. The left y-axis depicts the 7-point scale for concreteness and imageability. The right y-axis depicts the 5-point scale for MOA.

In order to answer the question on the specificity of MOA, correlations between MOA and concreteness and between MOA and imageability were calculated over words. The correlation between MOA and concreteness was -.47 ($p < .01$) and between MOA and imageability -.64 ($p < .01$). These results show that words with a high concreteness rating or a high imageability rating tend to have low MOA ratings, which is in accordance with the idea that such word meanings are learned through perception. Words with low imageability and low concreteness (i.e., higher abstractness) tend to have high MOA ratings, which suggests that linguistic information is necessary for the acquisition of their meanings. Although this relation is significant, it is far from perfect. Only 22% (r^2) of the variance in concreteness is explained by its correlation with MOA, which means that the remaining 78% has to be explained by other factors. For imageability, 40% of the variance is explained by MOA. These marginal correlations are not due to low reliability, because high loadings of the items on the respective factors (.71 to .78) were found and the intraclass correlations showed high reliability between ratings for each scale. Figures 4, 5, 6, and 7 show different distributions over grades for imageability and concreteness than for MOA. MOA showed an increase over grades, whereas concreteness and imageability did not show such an increase. Evidently, judgments of words in terms of MOA are different from judgments of words in terms of concreteness and imageability. Figures 5 and 6 show no difference in concreteness and imageability between grades. This may be explained by the fact that texts for the higher grades contain word meanings with high concreteness and/or high imageability that are judged to be learned through linguistic information (see Table 4 for examples). Although these words are highly concrete and/or highly imageable, they probably only occur in reading texts for higher grades (see Table 4), because their meanings have to be acquired through linguistic information.

MOA is usually related to age of acquisition (AOA). Because younger children are in a lower stage of language development, acquiring word meanings through linguistic information will be more difficult than it is for older children. Using data from Van Loon-Vervoorn (1985) and Krom (1990), it was possible to compare the MOA ratings with the AOA ratings for 444 words. As we expected, a significant correlation is found between the MOA and the AOA ratings ($r = .59$, $p < .01$). However, the former does not predict the latter completely, or vice versa. Only 35% (r^2) of the variance is explained by some relation between the two constructs. The remainder of the variance in MOA is not related to variation in AOA. As Table 5 shows, some words of which the meaning is judged to be learned through linguistic information are acquired before the age of 6.

Table 4. Highly concrete and highly imageable word meanings that are judged to be learned through linguistic information.

Words	Grade	Concreteness	Imageability	MOA
balsahout (balsa wood)[a]	6	5.70	2.93	4.60
buitenlander (foreigner)	6	5.80	5.14	4.00
interieur (van een huis; house interior)	6	5.70	5.14	4.56
inzittende (occupant)	6	5.70	5.07	4.20
kameraad (comrade)[b]	4	4.80	5.07	4.10
kapitein (captain)	1	6.50	6.29	4.20
kazerne (military barracks)	6	6.30	5.93	4.70
Koran ('bijbel' in de islam; Koran)[a]	4	6.40	4.57	4.40
land (geografisch; country)[a]	5	5.50	4.93	4.50
lieden (mensen; folk)[a]	6	5.70	4.29	4.60
natuur (nature)[b]	3	3.60	5.57	4.10
paleistuin (palace garden)	5	7.00	5.93	4.20
rondcirkelen (to circle)[b]	4	4.60	5.79	4.10
schedel (skull)	6	7.00	6.64	4.10
schrijver (writer)	4	5.30	5.71	4.10
slavin (female slave)	6	5.30	5.50	4.80
tekst (text)	6	5.40	5.93	4.10
tipi (indianentent; tepee)	6	6.90	5.71	4.70
training (oefening; training)[a]	3	5.00	4.71	4.10
troon (throne)	1	6.80	6.21	4.20
tros (van bloemen; raceme)	3	6.20	5.43	4.00
vluchteling (refugee)[a]	6	6.00	4.86	4.50
zaak (bedrijf; company)[a]	4	5.20	4.50	4.50

Note. Grade = grade level of the reading text that contained the word.
[a]Word meanings that are judged to be highly concrete (> 5), but not highly imageable (< 5).
[b]Word meanings that are judged to be highly imageable (> 5), but not highly concrete (< 5).

Table 5. Words acquired linguistically at an early age.

Words	MOA	AOA (in years)
geloven (to believe)	4.50	5
gelukkig (happy)	4.08	4
jaar (year)	4.08	4
jagen (to hunt)	4.00	5
land (land)	4.27	4
leven (life)	4.08	5
merken (to notice)	4.23	5
plan (plan)	4.00	4
poos (while [noun])	4.00	5
wereld (world)	4.27	5
zullen (shall)	4.23	5

Discussion

The educational professionals gave the same MOA ratings as did the students in Experiment 1. Factor scores, computed over the judgments of students and professionals separately, appear to be highly correlated, which demonstrates that students and professionals agree in their MOA ratings of the individual words.

As in Experiment 1, an increase with grade is found in the average MOA rating and in the proportion of high MOA ratings. Reading texts in Grades 4, 5, and 6 contain a higher proportion of linguistically acquired word meanings than reading texts in Grades 1, 2, and 3. Starting from Grade 4, reading texts contain more linguistically acquired word meanings than perceptually acquired word meanings. Beyond Grade 5, a sudden increase occurs in the proportion of word meanings acquired through linguistic information. These results again show that reading texts for the successive grades can be differentiated with respect to MOA.

As for our hypothesis on deaf children's reading comprehension difficulties, we must conclude from this experiment that the gradual increase of MOA over grades supports the gradual increase hypothesis rather than the accelerated increase hypothesis.

Furthermore, this experiment shows that MOA can be differentiated from concreteness and imageability. Although higher MOA ratings tend to correspond with lower imageability and lower concreteness (or higher abstractness), MOA is different from concreteness and imageability. MOA ratings increase over grades. A similar increase is not found for concreteness and imageability of the same words. This implies that word meanings rated as having been acquired linguistically are not always given a low concreteness or a low imageability rating. Most of the concrete or imageable word meanings judged to be acquired through linguistic information are found in reading texts in higher grades. Reading texts for the successive grades vary in the proportion of word meanings learned linguistically without these word meanings necessarily being less concrete and/or less imageable.

GENERAL DISCUSSION

This study demonstrates that MOA is a construct that can be reliably measured. Both experiments show that, when judging the same words, different participants generally agree on the MOA ratings. There even is a high agreement between students and educational professionals.

We would show some construct validity for MOA if, over the grades, the composition of reading texts shifts from a higher proportion of perceptually acquired word meanings to a relatively higher proportion of linguistically acquired word meanings. The results of Experiments 1 and 2 do indeed show an increase of mean MOA ratings over the successive grades of elementary school. Reading texts for the lower grades contain high proportions of perceptually acquired word meanings, whereas reading texts for higher grades contain high proportions of word meanings learned through linguistic information or through a combination of both forms of information.

The established difference between MOA and concreteness and imageability is additional evidence for the validity of the construct of MOA. Experiment 2 shows no differences between the words selected for the successive grades of elementary school in concreteness and imageability. The far from perfect correlations between MOA and concreteness and imageability and the fact that MOA ratings differ over the grades, but concreteness and imageability ratings do not, show that MOA is different from concreteness and imageability.

The main motivation for this study was the potential relevance of MOA for explaining deaf children's reading difficulties. Learning word meanings through linguistic context may take place through listening to adult conversations or through reading. Unfortunately, both these means are rather inaccessible to deaf children. As Weizman and Snow (2001) suggested, verbal explanation of the meaning of words results in better acquisition and understanding of those words. Because hearing parents often are not fluent in sign language in the first years of the deaf child's life, the young child is not likely to receive linguistic input from his or her parents. Therefore, acquiring or broadening concepts through a combination of perceptual and linguistic information or through linguistic information only is difficult for deaf children. The reception of verbal information required to reinforce the child's perceptually acquired word meanings and to build and properly extend these into linguistically acquired word meanings is restricted.

Besides explaining reading problems of the deaf, MOA might also explain text comprehension difficulties of other groups of children, for example ethnic minority children. Verhoeven (2000) claims that linguistic and conceptual knowledge is relevant to early literacy development. Chall (1987) states that children from low-income families, minorities, and bilinguals have great difficulty in acquiring word meanings, particularly at Grade 4 and beyond. Reading texts confront ethnic minority children with new and culturally specific concepts. Like native children, ethnic minority children will first learn the meaning of words through perception and at a later stage through linguistic information. Because these children learn the meaning of culturally specific words in their second language at a later age, the meaning of those words will be learned predominantly through linguistic information.

The results of Experiments 1 and 2 show a gradual change in MOA. Although we found a difference between mean MOA ratings in the lower three grades and ratings in the higher three grades, the accelerated increase hypothesis found no support. As we stated earlier, a change in MOA after third grade was to be expected because the emphasis in reading instruction shifts from decoding in Grades 1 to 3 to reading comprehension in Grades 4 to 6 (Van Bekkum, 1996; Droop, 1999). Instead of a sudden increase after Grade 3, the MOA curve showed such an increase after Grade 5. The sudden increase we found after Grade 5 could be explained by a change in emphasis of reading instruction from comprehending texts to using this comprehension for gaining knowledge from texts.

Detailed information on the way in which reading texts for the successive grades are distinguished by MOA suggests an earlier change than the acceleration we see in the MOA curve. Both experiments 1 and 2 show a change in the proportion of linguistically acquired word meanings in reading texts. In Grades 1 to 3, the proportion of perceptually acquired word meanings is higher than the proportion of linguistically acquired word meanings. In Grades 4 to 6, the proportion of linguistically acquired word meanings is higher than the proportion of perceptually acquired word meanings. These results support the gradual increase hypothesis. The high proportions of linguistically acquired word meanings in third grade texts may exceed the proportion of those words in the child's lexicon. Therefore, text comprehension fails. Reading difficulties of deaf children may occur when reading instruction shifts to reading comprehension and therefore, reading texts contain a higher proportion of linguistically acquired word meanings.

From this study we know that MOA can be reliably measured and that reading texts can be differentiated with respect to MOA. We will use this concept in examining deaf children's reading comprehension difficulties. Other areas in which the concept of MOA might be fruitful are, for example, in explaining reading difficulties in ethnic minorities or the effect of educational environment on vocabulary growth.

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MODE OF ACQUISITION AS A FACTOR IN DEAF CHILDREN'S READING COMPREHENSION[10]

Abstract

The present study examined the role of mode of acquisition (MOA) of words in reading comprehension. A self-paced reading task was administered to 161 deaf children between 7 and 19 years of age and 99 hearing children in Grades 2 to 6 of elementary school. For both groups, reading times on linguistically acquired words were longer than on perceptually acquired words. Comprehension scores increased with age in both hearing and deaf children. Reading speed increased over age only for the hearing participants. Although deaf children scored lower than hearing children in both conditions, comprehension scores for both groups were lower on linguistic items than on perceptual items. The difference between perceptual and linguistic items in reading time and in comprehension decreased over age for the hearing, but not for the deaf participants. MOA influences reading comprehension, but for deaf children even perceptual items cause difficulty.

Introduction

Studies in the United States and Great-Britain have shown that in reading comprehension, deaf adolescents perform at a level of average 9-year-old hearing students (Allen, 1986; Conrad, 1979; Holt, 1993; Holt, Traxler, & Allen, 1997; Karchmer & Mitchell, 2003; Traxler, 2000). Reading comprehension seems to show a leveling off at third or fourth grade level and the annual growth rate in reading comprehension is only 0.3 reading grade level (Paul, 2003). In a study in the Netherlands, the reading performance of deaf students was even lower, with an average performance at first grade level (Wauters, van Bon, & Tellings, in press). The present study examines whether *mode of acquisition*, a construct that is explained in depth below that refers to the way in which word meanings are acquired, contributes to these differences in reading comprehension between deaf and hearing students.

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[10] Reference: Wauters, L. N., Tellings, A. E. J. M., van Bon, W. H. J., & Mak, W. M. (2004). *Mode of acquisition as a factor in deaf children's reading comprehension*. Manuscript submitted for publication.

Studies agree on the low reading comprehension performance of deaf students and many factors have been proposed as explanations for this low performance. Paul (1997, 2003) states that causes for reading comprehension difficulties in deaf students can be found in three categories: reader-based factors, text-based factors, and task-based factors. Reader-based factors are prior knowledge, metacognition, working memory, phonological coding, and communication skills. Text-based factors are word identification, vocabulary, syntax, and figurative language. Task-based factors include the purpose of reading, the setting or time of testing, and the manner in which the reading will be measured. Deaf students have been found to have difficulties in more than one of these fields (Paul, 2003). We will only discuss studies on those reader- and text-based factors in deaf students that are most relevant to the present study.

The reader-based factor prior knowledge that refers to both passage-specific and topic-specific knowledge overlaps with the factor metacognition that refers to knowledge about topics, language, text structures, tasks, and expectations. Deaf students have been found to use less metacognitive strategies than hearing children and the strategies they do use are often inappropriate (Marschark, Lang, & Albertini, 2002; Paul, 2003). However, according to Strassman (1997), deaf students do not have enough opportunities to apply metacognitive strategies, because the texts they read in general do not require high-level strategies.

Deaf students have also been found to have a lower memory span than hearing students (Marschark & Mayer, 1998). While hearing people tend to rely on speech-based verbal coding in simple memory tasks, deaf people rely more on visuo-spatial memory codes (Marschark et al., 2002). Deaf people who rely on sign coding show shorter memory spans than deaf or hearing people who rely on speech coding. It is possible that "deaf and hearing individuals have the same working memory capacity, (…), but [that] fewer ASL signs than English words can be fit into the articulatory loop" (Marschark et al., p. 122).

Another reader-based factor is phonological coding. For hearing children, the development of word identification is dependent on their phonemic awareness (Adams, 1990; Bradley & Bryant, 1983; Caravolas, Hulme, & Snowling, 2001). If spoken language is not accessible, as is the case for most deaf children, access to phonological information is obstructed. The few studies that investigated the role of phonological coding in deaf children's reading found that the deaf students who use a phonological code in working memory tend to be the better readers (Paul, 2003). Lichtenstein (1998) found better deaf college students to rely mostly on speech coding, probably because phonological coding better represents the grammatical structure of English than sign coding does.

Apart from these reader-based factors, text-based factors also influence deaf children's reading comprehension. Word identification is one of these factors. If access to phonological information is obstructed, word identification can be expected to be poor. Studies on word identification in deaf students show varying results. Harris and Beech (1998) found deaf children between 4 and 6 years old to score lower than hearing children. Merrills, Underwood, and Wood (1994) found deaf 11- to 15-year-olds to score lower than age-matched hearing good readers, but they scored at the same level as age-matched hearing poor readers and higher than younger hearing children matched on reading comprehension. Burden and Campbell (1994) have found British deaf school leavers (with a mean age of 14 years and 6 months) to perform as fast and as accurately on a lexical decision task as chronological-age hearing peers. In college students, Fischler (1985) did not find any differences between deaf and hearing students either. In a Dutch study (Wauters et al., in press), only minor differences were found between deaf and hearing 7 to 20-year-olds on a lexical decision task.

Various studies on vocabulary reported lower vocabulary levels for deaf students than for hearing students (Kelly, 1996; Marschark et al., 2002; Paul, 1996). Not only do deaf children know fewer words than hearing students, they also tend to use more nouns and verbs than adjectives, adverbs, and conjunctions (Paul, 2003). This lower vocabulary level of deaf students seems to be related to their lower reading comprehension scores (Garrison, Long, & Dowaliby, 1997; Paul, 2003).

The text-based factor syntax has also been found to be problematic for deaf students. Berent (1996, 2001) found deaf children to have difficulties with verb inflectional processes, auxiliaries, relative clauses, and sentence types that deviate from the subject-verb-object (SVO) order. In such sentences, deaf students often choose the noun that is closest to the verb as the subject of a sentence.

A factor that is related to vocabulary and syntax is figurative language. Deaf students, especially those with a low level of reading comprehension, have been found to have difficulties understanding figurative language (Paul, 2003).

Mode of acquisition (MOA) is a vocabulary-related factor that may also play a role in deaf children's reading comprehension (Wauters, Tellings, van Bon, & van Haaften, 2003). The mode of acquisition of a word refers to the way in which children (or adults) acquire the meaning of that word. Word meanings can be learned through perception of the referents of the words, through linguistic information (i.e., through verbal or written explanation, description, or discussion of the referents), or through a combination of both. For some words, the MOA is determined by the nature of its referents. The meaning of color words, for example, will be learned almost entirely through perception, because no verbal description of colors can be given. The meaning of a word like *era* will be learned through linguistic information, because a verbal explanation is necessary to convey its meaning. For other words, the MOA is dependent on the context of acquisition. Children may learn the meaning of a word in different ways as a consequence of the time and place of acquisition or even the culture and social economic status of the child. The MOA of a word like *tundra*, for example, depends on the environment in which the word is learned. Children who live in a country with tundras will probably learn the meaning of *tundra* through perceptual information. However, in countries like the Netherlands, where tundras do not exist, the word will be learned linguistically or maybe through a combination of perceptual (through pictures) and linguistic information. In the present study, MOA will be treated as a learning environment-dependent characteristic of the acquisition of words rather than as a word characteristic.

Only few word meanings will be learned through perceptual information alone. Most word meanings are learned through a combination of perceptual and linguistic information or through linguistic information alone. Words will differ in the complexity of the linguistic information that is necessary to acquire the meaning. A child perhaps could learn the meaning of *caravan* entirely by seeing real caravans and going on vacation with a caravan. But not all parents have a caravan, and most children will learn the meaning of *caravan* by a combination of perceptual information and linguistic information. Someone will explain to the child that a caravan is a small house on wheels for vacations. Now, to understand this explanation the child must have acquired the word meanings *house*, *wheels* and *vacation*, and these word meanings probably will be learned through a combination of perceptual and linguistic information. And the linguistic part of learning these latter words in its turn requires the knowledge of relevant words, for instance *vacation* is *not-working or going to school* and is *doing fun things*. Thus, we can reconstruct hypothetical consecutive steps that are required in order to learn the meaning of a word. Now, it will be clear that learning a word meaning like *caravan* requires less consecutive steps than learning the meaning of a word like *guru* or *grammar*. Thus, word meanings are acquired through combinations of perceptual and linguistic information in more or less complex processes of consecutive steps. To phrase it differently: word meanings refer to concepts that differ with respect to their amount of perceptual and linguistic elements and with respect to their amount of linguistic layers. As children grow older, they learn more words and will be able to understand these words when learning other word meanings. In a previous study, Wauters et al. (2003) found a correlation of .59 between the mode of acquisition (as judged by educationalists) and age of acquisition of words, indicating that certain words that are acquired linguistically are acquired at a later age.

Acquiring word meanings through linguistic information requires access to language. For many deaf children of hearing parents, language access is scarce in the early years of life, because spoken language is inaccessible and sign language is not available (because parents only learn this language at a later point in the child's development). This limited access to language makes acquiring word meanings through linguistic information more difficult for deaf children than it is for hearing children. Therefore, deaf children's knowledge of these word meanings will be lower and understanding texts containing such words will be relatively difficult. Whether this is indeed the case will be examined in the present study.

In their theory of reading, the Simple View of Reading, Hoover and Gough (1990) identify two main components in reading comprehension: decoding and linguistic comprehension. Problems with one or both of these components would lead to difficulties in reading comprehension. Decoding refers to word recognition, while linguistic comprehension is "the ability to take semantic information at the word level and derive sentence and discourse interpretations" (Hoover & Gough, 1990, p.131). In languages with an alphabetic orthography, decoding is based on the principle that letters represent the phonological form of the word. Results from the above-discussed studies on word identification indicate that deaf children's reading comprehension difficulties cannot, or at least not fully, be explained by word identification problems. According to Hoover and Gough, this means that an explanation should be found in the linguistic component of reading comprehension. One aspect of linguistic comprehension is word knowledge. At this point, mode of acquisition may play a role in deaf children's reading comprehension. Burden and Campbell (1994) suggest that, because of the inaccessibility of spoken language, deaf students have a lack of age-appropriate inferential, contextual, and linguistic skills. In our opinion, a lack of (spoken) language access would also result in difficulty with acquiring word meanings through linguistic information. Therefore, text comprehension will fail when a reading text contains too many words of which the meaning is judged to be learned through linguistic information.

The present study uses a self-paced reading task to investigate the role of mode of acquisition in reading comprehension for both deaf and hearing participants. In a self-paced reading task participants read words or sentences on a computer screen at their own rate by clicking a button when they are ready for the next word. The specific format used is the moving window condition, in which successive words appear, not in the same place, but at consecutive places, and disappear from the screen after they are read. Each word is represented by dashes, one for each letter, before and after it is read. Just, Carpenter, and Woolley (1982) and Ferreira and Henderson (1990) found similar results in the moving window condition as in eye fixation studies, indicating that the self-paced reading procedure is a valid measure of sentence processing.

Although the self-paced reading procedure has been used primarily in adults, Beveridge and Edmundson (1989) used it to investigate reading strategies in 8- to 11-year-olds. Reading times were longer than would be expected in normal page reading, but the self-paced reading procedure showed the same differences between good and poor readers as normal page reading does.

In the present study, the self-paced reading procedure with the moving window condition is used to examine the role of MOA in text reading. More specifically, the reading times for words in sentences containing a perceptually acquired target word are compared to reading times of words in sentences containing a linguistically acquired target word. If MOA plays a role in reading comprehension, reading times on linguistically acquired words should be longer than on perceptually acquired words. More specifically, we investigate whether deaf and hearing participants differ in this respect. If deaf children indeed have more difficulty than hearing children in acquiring words through linguistic information, then, on average they will have less knowledge of these words than hearing children. Therefore, reading times for these words should be longer for them than for hearing children. Because measuring reading times with a self-paced reading task provides information about the processes of reading but not about the understanding of a word or sentence, we added a question after each item to assess comprehension. If MOA influences reading comprehension, MOA will affect both reading times and comprehension scores.

We expect longer reading times in the self-paced reading task and lower scores on the comprehension task for linguistically acquired words than for perceptually acquired words. On the perceptually acquired words no or only minor differences are expected between deaf and hearing children, because linguistic information is not indispensable to learn these words. However, the deaf participants are expected to show longer reading times and lower comprehension scores than the hearing participants on the linguistically acquired words, because language access is necessary to learn these words. In addition, we expect an age difference, because younger children know less words and their word identification skill is not yet fully automatic. Therefore, reading times of the younger participants (deaf or hearing) will be longer and their comprehension scores will be lower than for the older participants. Wauters et al. (2003) found a relation between MOA and age of acquisition. Some linguistic words will be learned at a later age, because only then do children have enough linguistic knowledge to learn these words. Therefore, the difference between perceptually and linguistically acquired words (in reading time and in score) will also change over age. Reading times on linguistically acquired words will be shorter and the comprehension scores will be higher at a later age. However, reading times and scores on the perceptually acquired words will not show a considerable change, because most of these words are already known at a younger age. This change in the difference between perceptually and linguistically acquired words will be stronger for the hearing than for the deaf participants, since the hearing children have more access to the linguistic information needed to acquire the linguistic words.

Method

Participants

Participants in this study were 161 deaf and 99 hearing children. Our purpose in selecting the participants was to include deaf and hearing children with average word identification performance compared to their instructional age group (within either the deaf or the hearing group). Instructional age refers to the school history of a child, defined by the number of years of formal instruction starting from first grade. Because reading instruction in deaf education does not always start at the same time as in hearing education, the use of instructional age is to be preferred over chronological age. An instructional age of one year means that a child has had 10 months of formal instruction.

The deaf participants were selected from a sample of 537 deaf participants of whom 394 were in schools for the deaf, 62 in schools for hard-of-hearing children, and 81 were in mainstream education. These 537 participants took a pencil-and-paper lexical decision test. Each item consisted of a pair of letter strings, one a highly frequent existing word and the other an (orthographically and phonologically legal) non-existent word. The task of the participant was to decide which was the non-existent word and to cross out that letter string. The score was the number of correctly judged word pairs in one minute (for more information on the task, see Wauters et al, in press). This easily applicable test was chosen as an alternative to reading aloud word identification tests to circumvent the problems deaf readers have in speech production and that test administrators have in judging the speech products of deaf readers. From the scores on this test, the range of one standard deviation below and above the mean was calculated for each instructional age group. Table 1 shows the mean scores on the lexical decision test for deaf children of each instructional age. For the instructional age of 2 years, 12 participants scored within the selection range and were selected for participation. For the instructional ages of 3 to 10 years, 15 children who scored within this range were selected for participation. In the instructional ages of 11 and 12 years, ten children were selected. Because only 19 participants in the sample of 534 had an instructional age above 13 years, these participants were taken together in one group. Of these participants, 12 scored within the range of one standard deviation below or above the mean of this pooled group and were selected for the present study.

Table 1. Mean scores of deaf and hearing participants on the word identification test.

Instructional age	Deaf		
	N	*M*	*sd*
2	12	19.75	4.65
3	15	21.40	3.81
4	15	25.53	4.53
5	15	31.60	5.44
6	15	33.93	6.10
7	15	35.13	4.05
8	14	40.93	6.21
9	15	44.87	6.57
10	14	49.64	6.83
11	10	44.90	6.35
12	10	45.90	6.90
13	11	50.18	12.16
Total	161	36.35	11.82

In total, 164 deaf children were selected. Three children were ill at both testing times and were excluded from the study. The remaining 161 children (79 female, 82 male) ranged in age from 7;2 to 19 years (mean = 12;10). Instructional ages ranged from 2 to 16 years (mean = 7). The mean hearing loss was 105 dB (ranging from 60 to 130). Eight children had a hearing loss of less than 80 dB, the boundary used to define deafness in the Dutch educational system. They were evenly distributed over the instructional ages and their hearing losses were 60, 63, 65, 70, 73, 75, and 77 dB respectively. Although these eight children also participated in the present study, we will use the term deaf in the rest of this article. Nineteen of the participants had a cochlear implant.[11] The mean performance IQ (M = 97.31, sd = 14.44) as reported by the schools and calculated using various instruments, did not significantly deviate from the standardization mean (100). Table 2 gives a list of relevant characteristics of the participants. No differences in IQ ($F(11,123) = 1.51$, $p > .05$) or hearing loss ($F(11,89) = .652$, $p > .05$) were found between the participants in the various instructional ages. Furthermore, χ^2 tests pointed out that no differences occurred in gender, ethnicity, prelingual or postlingual deafness, deaf or hearing parents, cochlear implants, current education (deaf, mainstream, or hard-of-hearing education), educational language, and home language (all $p > .05$).

Table 2. Characteristics of the deaf participants.

	Number of students
Onset of deafness	
Before the age of 3	99
After the age of 3	10
Missing values	52
Parents	
Both deaf	4
Both hearing	106
Hearing + deaf	1
Both hard-of-hearing	1
Deaf + hard-of-hearing	1
Missing values	48
Nationality	
Dutch	93
Other	22
Missing values	46
Current education	
School for deaf students	116
Mainstream	21
School for hard-of-hearing students	24

[11] A cochlear implant is a hearing aid with an external and an internal part. The external part receives sounds and translates those in an electric code. The internal part converts these electric codes into signals that are communicated to the hearing nerve through electrodes. A cochlear implant permits better perception of speech sounds and increases access to the segmental features of speech, which improves spoken linguistic performance.

The Grade 2 to 6 hearing participants came from two elementary schools. In both schools, the selection of the participants was based on their word identification competence. At the time of selection it was not possible to administer the lexical decision task that was used to select the deaf participants. However, in one school we were allowed to use the data of the children on a standardized oral reading test as a selection criterion. For each grade, 10 children scoring in the middle 50% of the norm group on this standardized oral reading test were selected. For Grade 6, 20 children were selected because the second school could not provide children for the sixth grade. In the other school, no such test data were available and selection of the participants was based on the teacher's judgment of word identification competence. The teachers of Grades 2 to 5 were asked to select 10 children with a mean word identification level. In total, 100 hearing children were to participate in the study, 20 for each instructional age (for the hearing participants, the instructional age in years corresponded to the grade). One participant from seventh grade was ill at both testing times and was excluded from the study, leaving 99 hearing participants (52 female, 47 male).

Materials

All participants took part in a self-paced reading experiment on a computer in which they had to read sentences and answer a question after each sentence they read. The experiment consisted of two testing sessions, with two weeks between the sessions. In each session 43 declarative sentences (in the remainder of the article referred to as sentences) and questions were presented. All sentences consisted of 7 words in which the fourth word was always the target word. The target word was either a high or a low MOA word.

In a previous study (Wauters et al., 2003), the MOA of a large set of words was determined by asking university students to rate them on a 5-point-scale from 'acquired through perception alone' (1) to 'acquired through linguistic information alone' (2). For the present experiment we selected 43 words with a mean MOA rating at or below 2 and 43 words with a mean MOA rating at or above 4. In the remainder of the paper, the first will be called perceptual words and the latter linguistic words. The mean rating of the 43 perceptual words was 1.68. For the linguistic words, the mean rating was 4.34. Both the perceptual and the linguistic target words consisted of 28 nouns, 12 verbs, and 3 adjectives (see the Appendix for a list of the perceptual and linguistic target words). Table 3 shows length and frequency of the target words in the two conditions.

Table 3. Mean length and frequency of the target words in each condition.

	Perceptually learned words			Linguistically learned words		
	N	*M*	*sd*	*N*	*M*	*sd*
Frequency	43	6866.1	11535.1	42	1049.3	1468.6
Number of letters	43	5.00	1.83	43	8.28	2.67
Number of syllables	43	1.67	0.61	43	2.74	1.05

Note. Frequency data were derived from CELEX, a lexical database for Dutch words (CELEX Dutch database, 1990).

Each sentence occurred twice: once with a perceptual target word in the one testing session and once with a linguistic target word in the other session. With the exception of the target word, these sentences were identical. In each testing session, half of the items consisted of sentences with a perceptual target word and the other half of sentences with a linguistic target word. If a sentence occurred in the first session with a perceptual target word, it was presented in the second session with a linguistic target word and vice versa. Sentences were presented in a random order. All sentences were written in the active voice and all but one were in the present tense.

After each sentence, a question with a yes-or-no format appeared on the screen. The questions were intended to probe the participant's knowledge of the meaning of the target word. Of the questions, 28 were directly related to the sentence the participant had read and referred to the meaning of the complete sentence. These questions were exactly the same in both the perceptual and linguistic condition. The other 15 questions referred to more general knowledge of the target word and were not related to the sentence the child read. In these cases, the target word was repeated in the question and, therefore, the questions were not exactly the same in both the perceptual and linguistic condition. All questions had the typical question format (verb-subject-object) in the present tense.

A (translated) example of a sentence in the perceptual condition is: "The boy smelled soup in the kitchen." The linguistic counterpart of this sentence is: "The boy smelled gas in the kitchen." The question that is presented after each of these sentences is read is: "Does the boy smell something that can be eaten?"

The experiment was conducted on a Macintosh Powerbook G3 with a three-button button box connected to it.

Procedure

All participants took part in both testing sessions of the experiment. To control for an order effect, half of the participants started with stimulus set 1 and the other half with set 2. The two item sets were administered with an interval of two weeks.

Each item started with an asterisk at the left side of the screen where the sentence would start. After pushing the middle button of the button box, the first word appeared together with a representation of the sentence with dashes for each letter, spaces between the words, and a period at the end. After pushing the button again, the next word appeared and the first one was replaced by dashes. Sentences were vertically centered and were presented in the Courier font, size 24. By using this non-proportional font, dash patterns and words were at exactly the same position after each button-click. When the last word of a sentence was read, another (middle) button-click revealed the question that had to be answered by pushing the button with the word *yes* (the left button) or the one with the word *no* (the right button). The reading times for each word were registered from the moment the child pushed the button to view that word until the child pushed the button again for the next word. Both the answers to the questions (yes/no) and the time it took to read and answer each question were recorded.

The test was administered individually by a test instructor who sat next to the child. At the start of the first session, the instruction was given in the modality preferred by the child (Sign Language of the Netherlands, Sign Supported Dutch, or spoken language). Three sample sentences were used to show the child how to use the button box and how the sentences would be presented on the screen. The child was instructed that a question would appear after each sentence and that he/she had to answer it by pushing the yes or no button. The correct answers to the questions about the sample sentences were explained to the child.

After the three sample sentences, the child started with ten practice sentences and answered the corresponding questions. To make sure that the child understood the intention of the test, the instructor discussed the given answers with the child. After the practice sentences the child started with the test sentences and no more help was provided.

Results

The present study investigated the effect of MOA on reading time of words in sentences and on the comprehension of questions about these sentences. The analyses that will be discussed in the results section focus on the difference in reading time between items containing a perceptually or linguistically acquired word. Reading times and scores of deaf and hearing participants will be compared to see whether MOA plays a different role for them. The effect of instructional age will also be taken into account in the analyses. For the discussion of the results, the two levels of MOA will be referred to as the perceptual condition and the linguistic condition.

Before analyzing the data, outliers were eliminated from the reading times data set by excluding all times that deviated more than 2 standard deviations from both the participant and the item means for a given condition at a given position. This was done for the deaf and hearing participants and for each condition separately. In both conditions, 1.7% of the reading times were removed for the deaf participants. For the hearing participants, 2.1% of the reading times were excluded in both conditions.

Next, the mean reading response latency was calculated for each participant on all first words, all second words, and so forth until the seventh word. This was done for the perceptual and the linguistic condition separately. For reading time, an effect of MOA was expected on the target word and possibly on the words after the target word. On the words before the target word, no MOA effect was to be expected. Therefore, analyses on the first three words of the sentences were not performed on each word separately but on the mean reading time for these first three words. Thus, sentence reading data were analyzed on the mean reading times for the first three words and on reading times for all subsequent words separately. Other dependent variables in the analyses were the reading times for the questions and the number of questions answered correctly. For analyses on the questions, a mean was calculated for the time it took to read and answer a question in each of both conditions. The latter means were calculated using the reading times in case of correct answers only. In addition, for the analyses on the answers the total comprehension score for each condition was used. Five of the deaf participants only completed one item set of the experiment, because of absence at the second test administration. For these participants, the reading times for the words were included in the calculation of the mean, but their scores on the questions were not included in the analyses.

For the instructional ages above 6 years, no hearing students participated in the study. Therefore, analyses concentrating on hearing status as a between-subjects factor only concerned the instructional ages of 2 to 6 years (72 deaf and 99 hearing participants). To study the effect of MOA for the total group of deaf students, including the older ones, additional analyses were performed on the data of the 161 deaf participants only.

We will first present the results on the reading times for the sentences. Then, results on the reading times for the questions and the scores on these questions will be discussed. Figure 1 shows the reading times of the deaf and hearing participants for each word in the sentences in both MOA conditions. This figure shows that, on average, the reading times for the fourth word, which is the target word, are longer in the linguistic condition than in the perceptual condition.

Data were analyzed according to a 2 x 2 x 5 repeated measures ANOVA, with reading time or comprehension score as the dependent variable, MOA (perceptual versus linguistic) as a within-subject factor and hearing status (deaf versus hearing) and instructional age (2 to 6 years) as between-subject factors. Separate analyses were done for each of the five reading times measured, based on the position of the word(s) in the sentence: the mean reading time of the first three words, fourth, fifth, sixth and seventh word. The outcome of the repeated measures analyses is presented in Tables 4 to 10. These tables show which factors and interactions are significant. Further analyses of the interaction effects will be described in the main text.

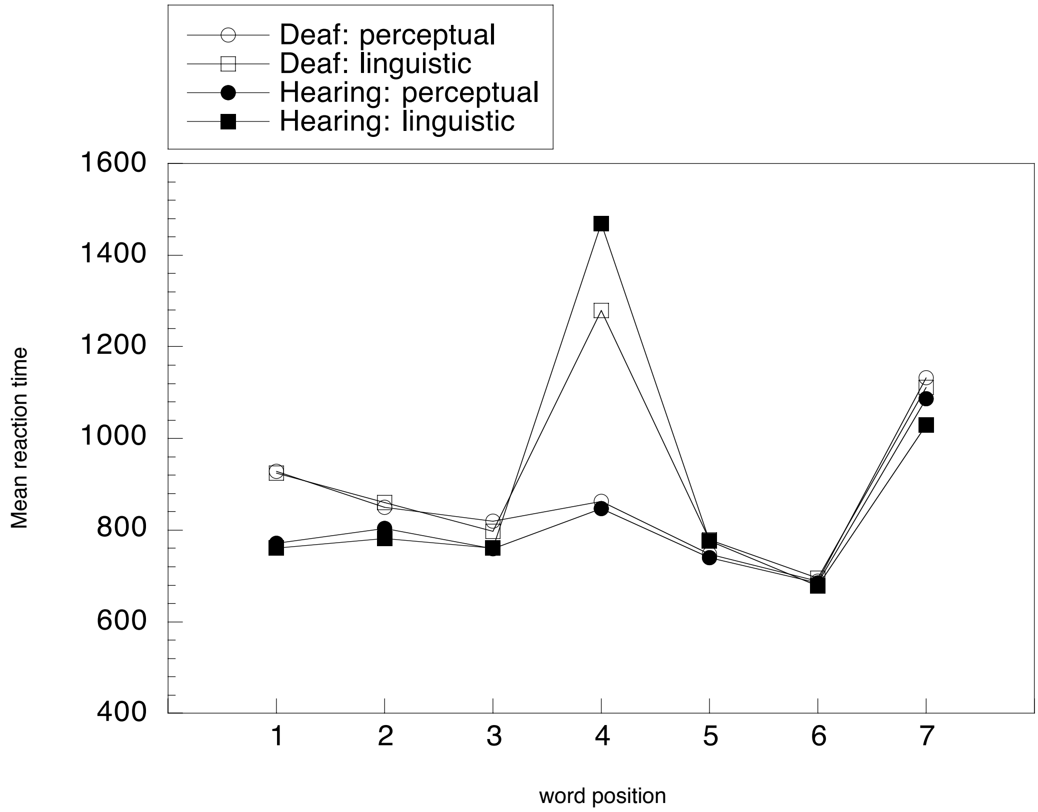

Figure 1. *Mean reading times for deaf and hearing participants on each word in the sentences for both conditions.*

For the mean reading time of word 1, 2, and 3, a main effect of hearing status was found with the deaf participants showing longer reading times than the hearing participants. The analysis also showed a main effect of instructional age, with a linear decrease in reaction time, and an interaction between hearing status and instructional age. One-way ANOVAs to analyze this interaction showed a significant effect of instructional age for the hearing ($F(4, 94) = 27.32$, $p < .001$, $\eta^2 = .54$), but not for the deaf participants ($F(4, 67) = 1.39$, $p > .05$, $\eta^2 = .08$). Polynomial contrasts (for the hearing participants only) showed a linear decrease in reading time over instructional age ($p < .001$) and a positive quadratic effect ($p < .05$), indicating that the decrease in reading time amplified over the instructional ages.

Table 4. Analysis of variance for the mean reading times of word 1, 2, and 3.

Source	*df*	*F*	η^2	*p*
		Between subjects		
Hearing status (H)	1	6.06^{*}	.036	.015
Instructional age (IA)	4	10.36^{**}	.205	.000
H x IA	4	3.16^{*}	.073	.016
Error	161	(127928.326)		
		Within subjects		
MOA (M)	1	3.30	.020	.071
M x H	1	0.52	.003	.470
M x IA	4	2.16	.051	.076
M x H x IA	4	1.21	.029	.310
Error	161	(1327.845)		

Note. Values in parentheses represent mean square errors.
$^{*}p < .05$, $^{**}p < .001$

Table 5. Analysis of variance for word 4.

Source	*df*	*F*	η^2	*p*
		Between subjects		
Hearing status (H)	1	1.46	.009	.229
Instructional age (IA)	4	10.46^{**}	.206	.000
H x IA	4	8.35^{**}	.172	.000
Error	161	(401518.63)		
		Within subjects		
MOA (M)	1	235.29^{**}	.594	.000
M x H	1	9.56^{*}	.056	.002
M x IA	4	7.70^{**}	.161	.000
M x H x IA	4	10.88^{**}	.213	.000
Error	161	(94089.10)		

Note. Values in parentheses represent mean square errors.
$^{*}p < .05$, $^{**}p < .001$

Analyses for word 4, the target word, showed main effects of MOA and instructional age. Reading times on target words in the linguistic condition (1389 ms) were longer than in the perceptual condition (853 ms) (see Figure 2) and a linear decrease in reading time was found over instructional age ($p < .001$). Interactions were found between MOA and hearing status, between hearing status and instructional age, and between MOA and instructional age. The effect of MOA was larger for the hearing than for the deaf participants ($F(1, 169) = 6.29$, $p < .05$, $\eta^2 = .04$) and the effect of instructional age was found for the hearing participants only ($F(4, 94) = 36.09$, $p < .001$, $\eta^2 = .61$). Analyses also showed a three-way-interaction of MOA, hearing status, and instructional age. The interaction between MOA and instructional age was only found to be significant for the hearing participants ($F(4, 94) = 28.52$, $p < .001$, $\eta^2 = .55$) and not for the deaf participants ($F(4, 67) = 1.11$, $p = .359$, $\eta^2 = .06$). The difference between the perceptual and linguistic condition decreased over age for the hearing, but not for the deaf participants. Polynomial contrasts over conditions showed a linear decrease ($p < .001$) and a positive quadratic effect ($p < .01$) of instructional age for the hearing participants, indicating amplification in the decrease of reading time. Figure 2 suggests that the interaction between MOA and instructional age for the hearing participants might be due to the reading times of participants with an instructional age of two or three years. However, an interaction was still found when participants with an instructional age of two and three years were excluded from the analysis ($F(2, 56) = 6.78$, $p < .01$, $\eta^2 = .19$).

Analyses for word 5 showed main effects of MOA and instructional age and an interaction of hearing status and instructional age. Reading times on words in the linguistic condition were longer than on words in the perceptual condition, and reading times decreased over instructional age. The interaction between hearing status and instructional age was further analyzed by one-way ANOVAs for the deaf and hearing participants separately. A significant effect of instructional age was found for the hearing participants ($F(4, 94) = 20.06$, $p < .001$, $\eta^2 = .46$), but not for the deaf participants ($F < 1$). For the hearing participants, polynomial contrasts once more showed a linear decrease in reading times over the instructional ages ($p < .001$).

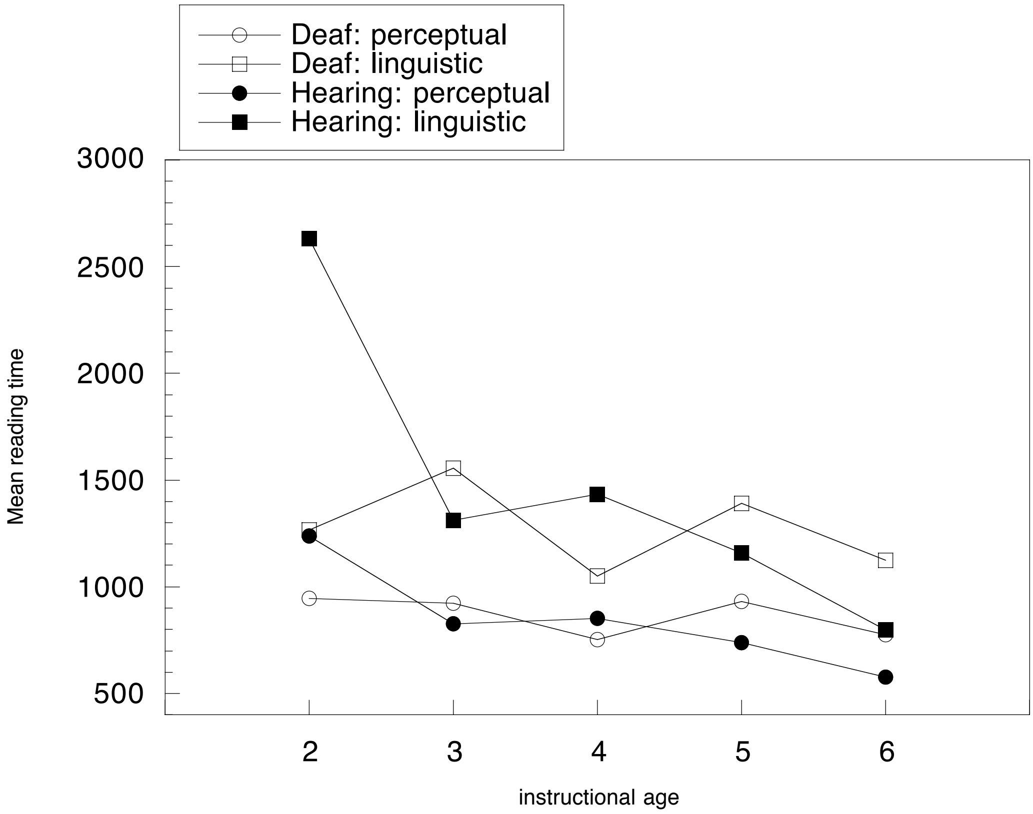

Figure 2. *Mean reading times for deaf and hearing participants on the target word in both conditions by instructional age.*

Analyses for word 6 showed a main effect of instructional age. Further, an interaction of MOA and instructional age was found. In both conditions reading times decreased linearly over the instructional ages (both $p < .001$). Results also showed an interaction between hearing status and instructional age. The effect of instructional age was found to be significant for the hearing participants ($F(4, 94) = 24.36$, $p < .001$, $\eta^2 = .51$), but not for the deaf participants ($F(4, 67) = 1.16$, $p = .33$, $\eta^2 = .07$). Polynomial contrasts for the hearing participants showed a significant linear decrease in reading times over the instructional ages ($p < .001$).

Table 6. Analysis of variance for word 5.

Source	*df*	*F*	η^2	*p*
		Between subjects		
Hearing status (H)	1	0.07	.000	.791
Instructional age (IA)	4	7.89^{**}	.164	.000
H x IA	4	3.35^{*}	.077	.011
Error	161	(85912.02)		
		Within subjects		
MOA (M)	1	28.74^{**}	.151	.000
M x H	1	0.13	.001	.716
M x IA	4	1.10	.027	.359
M x H x IA	4	0.58	.014	.681
Error	161	(3232.60)		

Note. Values in parentheses represent mean square errors.
$^{*}p < .05$ $^{**}p < .001$

Table 7. Analysis of variance for word 6.

Source	*df*	*F*	η^2	*p*
		Between subjects		
Hearing status (H)	1	0.23	.001	.634
Instructional age (IA)	4	10.07^{**}	.200	.000
H x IA	4	3.64^{*}	.083	.007
Error	161	(72890.37)		
		Within subjects		
MOA (M)	1	0.08	.001	.773
M x H	1	2.68	.016	.103
M x IA	4	2.57^{*}	.060	.040
M x H x IA	4	1.21	.029	.308
Error	161	(1334.82)		

Note. Values in parentheses represent mean square errors.
$^{*}p < .05$ $^{**}p < .001$

For word 7, a main effect of MOA and of instructional age was found. Here, reading times in the perceptual condition (1105 ms) were longer than in the linguistic condition (1064 ms) and reading times decreased over the instructional ages. Interactions were found between MOA and instructional age and between hearing status and instructional age. In both conditions reading times decreased linearly over the instructional ages (both $p < .001$). One-way ANOVAs showed that an effect of instructional age only occurred in hearing participants ($F(4, 94) = 25.82$, $p < .001$, $\eta^2 = .52$), not in deaf participants ($F(4, 67) = 1.99$, $p = .11$, $\eta^2 = .11$). Polynomial contrasts for the hearing participants showed a linear decrease in reading time over the instructional ages ($p < .001$) and a positive quadratic effect ($p < .01$).

Table 8. Analysis of variance for word 7.

Source	*df*	*F*	η^2	*p*
		Between subjects		
Hearing status (H)	1	1.25	.008	.266
Instructional age (IA)	4	9.59^{**}	.192	.000
H x IA	4	5.31^{**}	.116	.000
Error	161	(310715.75)		
		Within subjects		
MOA (M)	1	15.74^{**}	.089	.000
M x H	1	2.79	.017	.097
M x IA	4	2.76^{*}	.064	.030
M x H x IA	4	0.59	.014	.670
Error	161	(8770.26)		

Note. Values in parentheses represent mean square errors.

$^{*}p < .05$ $^{**}p < .001$

Summarizing the results on the sentences shows that for word 4 the effect of MOA proved to be larger for the hearing than for the deaf participants and the effect of instructional age only obtained for the hearing participants. The difference between the perceptual and linguistic condition decreased over age for the hearing but not for the deaf participants. For word 5, the effect of MOA did not significantly differ for hearing and deaf participants. For word 7, the reading times were shorter in the linguistic condition than in the perceptual condition. An effect of instructional age was found for all words, but interactions between hearing status and instructional age showed that differences in instructional age only obtained for the hearing participants. This effect was characterized by a linear decrease in reading time over the instructional ages. An effect of hearing status was only found for the mean reading time on words 1, 2, and 3 with the deaf participants reading slower than the hearing.

Figure 3 shows the response latencies for reading and answering the questions. The reading times on the questions showed main effects of MOA, hearing status, and instructional age. Reading times were longer in the linguistic condition (5048 ms) than in the perceptual condition (4243 ms) and the reading times of the deaf participants were longer than those of the hearing participants. Polynomial contrasts showed a linear decrease in reading time over the instructional ages ($p < .001$). No interactions were found.

The comprehension scores (number of questions answered correctly) are presented in Figure 4. Analyses for the scores showed main effects of MOA, hearing status, and instructional age. The scores were lower in the linguistic condition than in the perceptual condition and the scores of the deaf participants were lower than those of the hearing participants. The scores showed a linear increase over instructional age. Apart from the main effects, a three-way-interaction was found between MOA, hearing status, and instructional age. An interaction between MOA and instructional age was found for the hearing participants ($F(4, 94) = 16.27$, $p < .001$, $\eta^2 = .41$), but not for the deaf participants ($F(4, 67) = 1.48$, $p = .22$, $\eta^2 = .08$). This showed that the difference between the perceptual and linguistic condition diminished over instructional age for the hearing, but not for the deaf participants. An effect of MOA and instructional age was found for both deaf and hearing participants. For both deaf and hearing participants, polynomial contrasts showed a linear increase in scores over instructional age ($p < .01$ and $p < .001$ respectively). However, Figure 4 shows that the hearing participants with an instructional age at or above 4 years scored at ceiling level in the perceptual condition.

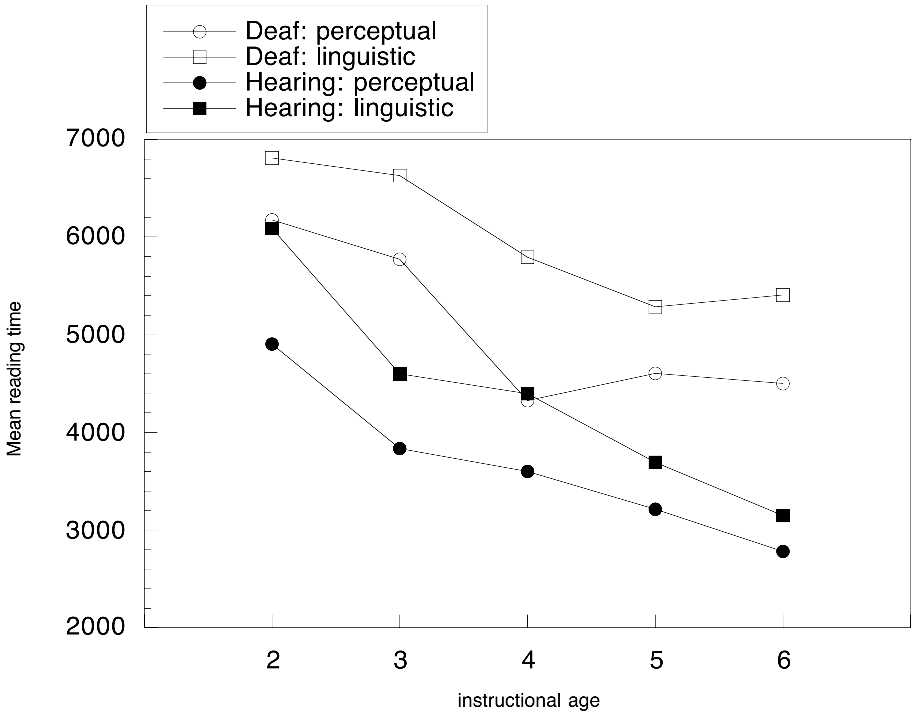

Figure 3. *Mean reading times for deaf and hearing participants on the questions in both conditions by instructional age.*

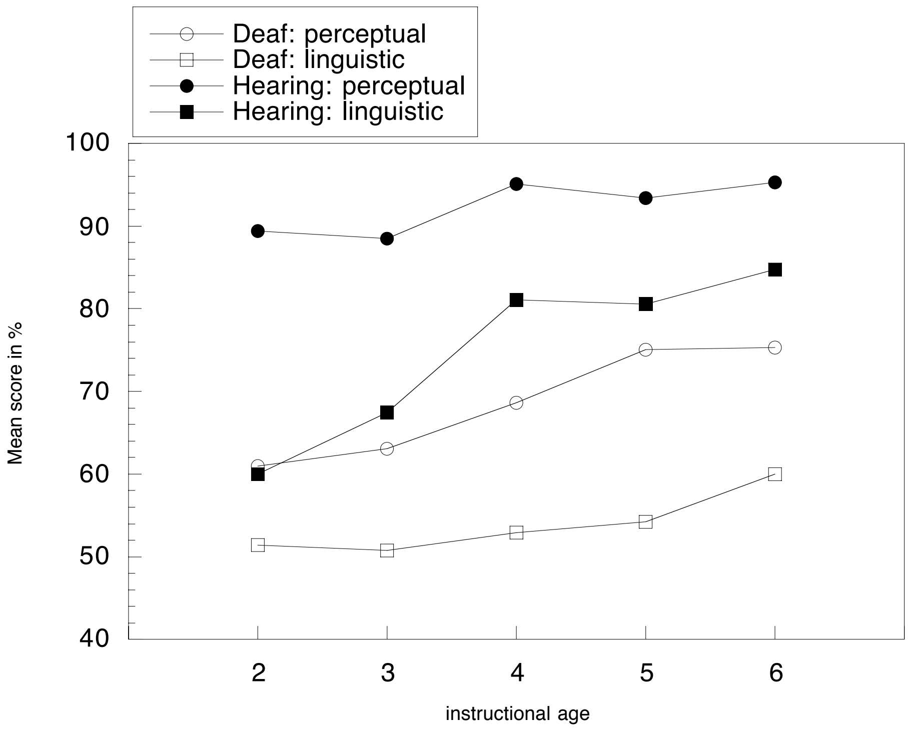

Figure 4. *Mean comprehension scores for deaf and hearing participants in both conditions by instructional age.*

Table 9. Analysis of variance for the questions.

Source	*df*	*F*	η^2	*p*
		Between subjects		
Hearing status (H)	1	45.92**	.222	.000
Instructional age (IA)	4	10.63**	.209	.000
H x IA	4	0.93	.023	.448
Error	161	(4094337.28)		
		Within subjects		
MOA (M)	1	114.65**	.416	.000
M x H	1	1.58	.010	.210
M x IA	4	1.74	.041	.144
M x H x IA	4	1.88	.044	.117
Error	161	(479290.058)		

Note. Values in parentheses represent mean square errors.
$^{*}p < .05$ $^{**}p < .001$

Table 10. Analysis of variance for score.

Source	*df*	*F*	η^2	*p*
		Between subjects		
Hearing status (H)	1	253.52**	.612	.000
Instructional age (IA)	4	13.01**	.244	.000
H x IA	4	1.04	.025	.387
Error	161	(162.86)		
		Within subjects		
MOA (M)	1	391.84**	.709	.000
M x H	1	3.04	.019	.071
M x IA	4	1.75	.042	.141
M x H x IA	4	9.27**	.187	.000
Error	161	(55.25)		

Note. Values in parentheses represent mean square errors.
$^{*}p < .05$ $^{**}p < .001$

In summary, main effects of all factors were found for the reading times and comprehension scores for the questions and all effects were found to be in the expected directions. Reading times were longer and scores were lower in the linguistic condition than in the perceptual condition. Reading times for the deaf participants were longer and their comprehension scores were lower than for the hearing participants. Reading times decreased and comprehension scores increased over the instructional ages. For the comprehension scores, analysis on the three-way interaction showed that the difference between the perceptual and the linguistic condition changed over age for the hearing participants, but not for the deaf participants.

The target words in the two conditions were found to differ in length and frequency (see Table 3). Therefore, it is possible that the effects we found cannot be completely ascribed to MOA. In order to verify the above reported MOA-effects, we selected a subset of items that was matched for length and frequency. All item pairs of which at least one target word was extremely long or short or had an extremely high or low frequency were excluded. After matching, 14 item pairs remained with a mean length of 5.6 letters for the perceptually acquired words and 6.2 for the linguistically acquired words. The mean frequency of use was 2377 for the perceptually acquired words and 2016 for the linguistically acquired words.[12] The same repeated measures analyses were performed as over the full item sets. Results showed the same main effects and interactions as before selection, except for the disappearance of the main effect of MOA for word 7 ($F(1,161) = 1.99$, $p > .05$, $\eta^2 = .01$) and of the interaction between MOA and instructional age for word 6 ($F(4,161) = 0.28$, $p > .05$, $\eta^2 = .01$) and 7 ($F(4,161) = 0.33$, $p > .05$, $\eta^2 = .01$). For word 4, the mean reading time in the perceptual condition was 892 milliseconds contrasting to a mean of 1139 milliseconds in the linguistic condition. These results indicate that the effects with the complete item sets can be ascribed to MOA.

All analyses discussed so far were performed with deaf and hearing students at the instructional ages of two to six years. To examine the effects of MOA and instructional age in the total group of deaf participants, additional analyses were performed with these

[12] Frequency data were derived from the CELEX Dutch database (1991) in which the range of frequencies for verbs, nouns, and adjectives is 0 - 852027.

participants only. The effects of MOA for word 4 to 7 were the same as in the analyses with deaf and hearing students. An unexpected difference was found for the mean of the words 1-2-3 where reading times were longer in the perceptual condition (801 ms) than in the linguistic condition (792 ms) ($F(1,149) = 4.47$, $p < .05$, $\eta^2 = .03$). This finding is inexplicable, because the first three words of the sentences were exactly the same in the two conditions. Only the fourth word was the target word, thus, only from that point could an effect of MOA on reading time be expected. Effects of instructional age were found for the mean reading time for words 1-2-3 ($F(11,149) = 2.01$, $p < .05$, $\eta^2 = .13$) and also for word 7 ($F(11,149) = 2.81$, $p < .05$, $\eta^2 = .17$), the questions ($F(11,149) = 2.74$, $p < .05$, $\eta^2 = .17$), and the comprehension scores ($F(11,149) = 4.65$, $p < .001$, $\eta^2 = .26$). The reading times showed a linear decrease over the instructional ages ($p < .01$ for words 1-2-3 and $p < .001$ for word 7 and the questions). The comprehension scores showed a linear increase ($p < .001$), but this increase reduced with instructional age ($p < .01$). No interactions were found between MOA and instructional age. The results indicate that an effect of MOA is found for the deaf students and that, in both conditions, the comprehension scores of the deaf students increased with instructional age. However, no decrease in reading time over instructional age was found for the target words.

Discussion

The present study investigated the role of mode of acquisition in reading comprehension for deaf and hearing students. We expected longer reading times in the self-paced reading task and lower comprehension scores for items with a word that is judged to be learned linguistically than for items with a word that is judged to be learned perceptually. On the perceptually acquired words no or only minor differences were expected between deaf and hearing children. However, on the linguistically acquired words, the deaf children were expected to show longer reading times and lower scores than the hearing children. We also expected a difference in instructional age, reflected in a decrease in reading time and a decrease in the difference between perceptually and linguistically acquired words, especially for the hearing participants.

Results on reading times for the target word show effects of MOA for both deaf and hearing students. Reading times are longer for linguistically acquired words than for perceptually acquired words, but this difference is unexpectedly larger for the hearing than for the deaf participants. A decrease in reading time over instructional age is also found, but this effect was only found for the hearing participants. Moreover, the difference between perceptually and linguistically acquired words decreases over instructional age for the hearing participants, but not for the deaf participants.

As for the answers on the questions, comprehension scores on the linguistic items are lower than on the perceptual items and, overall, the deaf participants score lower than the hearing participants. Although no differences are found in reading times between the deaf and hearing participants, the comprehension scores of the deaf participants are lower than those of the hearing participants on both the perceptual and the linguistic items. A linear increase in comprehension scores is found over instructional age for both deaf and hearing participants. The situation is complicated though, because a three-way interaction for the comprehension scores shows a decrease in the difference between the perceptual and the linguistic condition for the hearing participants only. This decrease for the hearing participants may be caused by a ceiling effect for the perceptual items from the instructional age of four years onwards.

These results show that MOA influences sentence reading time and sentence comprehension for both deaf and hearing participants. Both groups show longer reading times for words of which the meaning is thought to be learned linguistically than for words of which the meaning is thought to be learned perceptually. This effect remains when a subset of items matched for length and frequency is used, which indicates that MOA influences reading comprehension.

Apparently, the hearing participants know the meaning of the perceptual words in the present study at an instructional age of four years, as can be derived from the ceiling effect in comprehension scores from that point onwards. However, the mean reading time on the perceptual target words still decreases after an instructional age of four years. Maybe hearing children with an instructional age of four years have enough knowledge of the perceptual words to answer the questions correctly, but their reading time can still decrease when they learn more about the meaning of the words. For the deaf participants the comprehension scores also show an increase over instructional age, but they have less knowledge than the hearing participants of both the perceptual and the linguistic words, even at an instructional age of 10 years. Even for the total group of deaf participants, no change occurs over instructional age in the difference between perceptual and linguistic items.

Possibly, the decrease in reading time in the perceptual condition for hearing participants is caused by an increase in word identification. To check this explanation, we used the mean reading time on the first three words as a covariate in an analysis of variance with instructional age as the independent and reading time as the dependent variable. Because the target word is not yet read at this point, reading times should only reflect reading fluency in the first three words. These additional analyses showed that with reading time on the first three words as a covariate, the effect of instructional age only remained for the hearing participants in the linguistic condition ($F(4,94) = 6.09$, $p < .001$, $\eta^2 = .21$). This indicates that the decrease in reading time in the perceptual condition is caused by an improvement in reading fluency. However, in the linguistic condition reading times still decrease indicating that more than reading fluency plays a role here, probably the acquisition of the meaning of the word. Knowledge of the word meanings seems to be a prerequisite for a decrease in reading time. Since the deaf participants have not acquired enough knowledge of the word meanings, their reading times do not decrease.

The present study confirms results from previous studies in which the reading comprehension performance of deaf children was found to be lower than the performance of hearing children. The simple view of reading suggests that problems in reading comprehension are caused by problems in word recognition, in linguistic comprehension, or in both. Previous studies found that word recognition cannot fully explain deaf children's low reading comprehension skill. Therefore, linguistic comprehension should, at least partly, explain reading comprehension problems. According to Hoover and Gough, the ability to obtain semantic information at the word level is one aspect of linguistic comprehension. To take semantic information, a child has to know the meaning of words and this may depend at least partly on the way word meanings have been acquired. Only few word meanings are learned through perception only, probably only color words and names. To learn the meaning of all other words, varying degrees of linguistic information, with varying complexity, are necessary. The perceptual words used in the present study are words that have been categorized as acquired mainly through perception and only partly through linguistic information. Our hypothesis was that deaf children would not differ much from hearing children on these words. However, it turns out that deaf children's performance on these words is also low. The amount of linguistic information that is necessary to acquire the meaning even of these words seems to be too large for the deaf children. Perception of the referents of these words might not be enough to compensate for the necessary linguistic information. Or perhaps much more extra perceptual information than usually is provided to deaf children is necessary for compensating the lack of linguistic information.

A possible argument against the explanation for deaf children's low scores in both the perceptual and linguistic condition could be that deaf children usually have a lower memory span than hearing children and that this would be reflected in the results on a self-paced reading task. Differences in memory span might indeed explain differences in score between deaf and hearing participants, but they cannot explain the three-way interaction that was found. Furthermore, a possible influence of memory span should be the same for both conditions because the perceptual and linguistic target words appeared in identical sentences. Another indication that memory span is not the explaining factor here is that deaf and hearing participants do not differ in reading time on the last word of the sentences. At this point, readers 'wrap up' what they have read. If deaf children's memory impedes their reading and comprehension of sentences, this should have been reflected in the wrapping up process. These results indicate that the differences found in the scores in both conditions are most probably not caused by memory differences.

The present study investigated the role of MOA in deaf and hearing children. Differences in the selection of these two groups may have influenced the results. However, in studying the role of a relatively new construct such as this, it is necessary to test deaf and hearing children that are representative for their population. Comparison groups now were matched for their instructional age, i.e., the number of years of formal instruction starting from first grade. The resultant groups undoubtedly differed in many other respects, like IQ and reading level. Matching the two groups on additional characteristics, however, would probably lead to biased results. It is important in subsequent studies on the role of MOA to investigate the effects of differences in such characteristics between deaf and hearing participants.

The present study again shows the importance of abundant and rich concept formation for children as a prerequisite for reading comprehension. Deaf children, obviously, have considerable problems in this area. The construct of MOA proves to be a useful tool in this respect.

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APPENDIX

Pairs of perceptual and linguistic target words as they appeared in identical sentences.

Perceptual	Linguistic
cola (coca cola)	basisvoedsel (basic food)
poetsen (to clean)	betrekken (to move into)
oma (grandmother)	herbergier (innkeeper)
man (man)	wereldnieuws (world news)
zingen (to sing)	overleven (to survive)
hond (dog)	onderdaan (subject/nation citizen)
blauw (blue)	apart (unusual)
lachen (to smile)	spijbelen (to skip school)
beer (bear)	malariaparasiet (malaria parasite)
aaien (to stroke)	jagen (to hunt)
lopen (to walk)	studeren (to study)
slapen (to sleep)	onderduiken (go into hiding)
vallen (to fall)	profiteren (to profit from)
koud (cold)	fiks (firm)
dier (animal)	prooi (prey)
moeder (mother)	slavin (female slave)
eend (duck)	graansoort (grain)
juf (female teacher)	ambtenaar (public servant)
wind (wind)	orkaankracht (hurricane force)
achterdeur (backdoor)	interieur (house interior)
nat (wet)	bar (severe)
opa (grandfather)	vulkaan (volcano)
vlag (flag)	tijdperk (era)
slaapkamer (bedroom)	zomerverblijf (summer residence)
appeltaart (apple pie)	bestelling (order)
kind (child)	kameraad (comrade)
soep (soup)	gas (gas)
gapen (to yawn)	omkomen (to perish)
schapen (sheep)	lieden (folk)
dak (roof)	grondvlak (base)
gillen (to scream)	lijden (to suffer)
water (water)	afvalstof (waste product)
eten (to eat)	bezorgen (to deliver)
vogel (bird)	tipi (tepee)
ei (egg)	loodje (het loodje leggen; get the short end of the stick)

Perceptual	Linguistic
poes (cat)	vluchteling (refugee)
bos (forest)	kazerne (barrack)
sloot (ditch)	geluidswal (sound barrier)
bellen (to call)	beschermen (to protect)
huilen (to cry)	slagen (to pass)
knikker (marble)	korting (discount)
muziek (music)	cultuur (culture)
keuken (kitchen)	oppervlakte (surface)

FACTORS IN DEAF AND HEARING CHILDREN'S READING COMPREHENSION: THE EXPLANATORY POWER OF MODE OF ACQUISITION.[13]

Abstract

The present study examines whether specific item characteristics, such as mode of acquisition (MOA) of word meanings, make reading comprehension tests particularly difficult for deaf children. Reading comprehension data of 12853 hearing and 253 deaf children are analyzed, divided over test levels from second grade to sixth grade. Factor analyses over item scores suggest only one factor attributing to the reading comprehension scores for both deaf and hearing children. Of the determinants studied, MOA is the only one significantly contributing to deaf and hearing children's reading comprehension. For the hearing children, MOA influences item scores at third and fourth grade level. For the deaf children, MOA influences the item scores through the sixth grade level.

Introduction

Deaf children have been found to perform poorly on reading comprehension (Allen, 1986; Karchmer & Mitchell, 2003; Traxler, 2000) with an average score for school-leavers at the level of third or fourth grade of elementary school for hearing children. The decisive factors for these difficulties are yet to be determined, but there is reason to believe that it is not differences in printed word identification that explain these lower reading comprehension scores (Burden & Campbell, 1994; Merrills, Underwood, & Wood, 1994; Wauters, van Bon, & Tellings, in press). To explain the low reading comprehension scores, the present study investigates whether specific item characteristics make reading comprehension tests particularly difficult for deaf children. Using the data of Wauters et al. (in press) that showed 7- to 20-year-old Dutch deaf pupils to score far below hearing children on a standardized reading comprehension test, we will examine whether the items of the reading comprehension test can be categorized along certain

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dimensions and whether one or more of these dimensions in particular discriminate between deaf and hearing readers.

A previous study by Wauters, Tellings, van Bon, and Mak (2004) showed the mode of acquisition (MOA) of word meanings to play a role in sentence comprehension for deaf and hearing students. The present study again examines the explanatory role of MOA in reading.

Mode of acquisition, as introduced by Wauters et al. (2003), refers to the way in which children or adults acquire the meanings of words. Word meanings can be learned through perception of the referents of the words, through linguistic information (i.e., through verbal or written explanation, description, or discussion of the referents), or through a combination of both. For both deaf and hearing children, MOA has been found to influence sentence comprehension (Wauters, Tellings, et al., 2004). Reading words that are thought to be learned linguistically takes longer than reading words that are thought to be learned through perception. Moreover, comprehension of sentences containing a word that is thought to be learned linguistically is more difficult than comprehension of sentences with a word that is acquired through perception. If MOA influences sentence comprehension it will most likely also influence comprehension of a complete text and questions about that text. The present study investigates whether the MOA of test items in a reading comprehension test influences deaf and hearing students' scores on that test and whether differences between deaf and hearing students can be attributed to differences in MOA.

According to some reading researchers (Long, Seely, Oppy, & Golding, 1996; Underwood & Batt, 1996; van Dijk & Kintsch, 1983; Zwaan, 1996), reading consists of three levels of text representation: identification (at the word level), comprehension (at the sentence level), and interpretation (at the text level). The first level involves word identification, the ability to identify printed words. Prerequisite for understanding a text is an accurate and automatic word identification process. Word identification has been found to correlate highly with reading comprehension, indeed, especially in the lower grades of elementary school (de Jong & van der Leij, 2002; Hoover & Gough, 1990). Deaf children's word identification skills have been found to be only slightly below that of hearing children (Burden & Campbell, 1994; Merrills, Underwood, & Wood, 1994;

Wauters et al., in press), indicating that reading comprehension problems do not stem from word identification problems.

The second level of text representation consists of understanding the meaning of the words in a sentence and combining these meanings into propositions. Vocabulary and syntax can be expected to be important contributors to success at this level. Vocabulary has indeed been found to be an important factor in reading comprehension. Aarnoutse and van Leeuwe (1988) even found vocabulary to be the most important predictor of reading comprehension. De Jong and van der Leij (2002) also found significant correlations between word knowledge and reading comprehension in Grades 1 and 3. Deaf children often have lower vocabulary levels than hearing children (Kelly, 1996; Marschark, Lang, & Albertini, 2002; Paul, 2003). Furthermore, deaf children's vocabulary knowledge has been found to significantly influence their reading comprehension abilities (Garrison, Long, & Dowaliby, 1997; Paul, 2003). Deaf children also encounter difficulties with respect to syntax, especially with verb inflectional processes, auxiliaries, relative clauses, and sentence types that deviate from the subject-verb-object order (Berent, 1996, 2001).

The third level of text representation concerns making inferences to interpret the meaning of a text. The ability to make inferences has been found to vary with reading ability (Cain & Oakhill, 1999; Long et al., 1996). According to Cain and Oakhill (1999), two kinds of inferences should be distinguished: text-connecting and gap-filling inferences. Text-connecting inferences require the ability to integrate information that is explicitly provided in the text in order to establish cohesion between different sentences. Gap-filling inferences require incorporation of information outside the text – general knowledge – with information in the text to fill the gaps. Cain and Oakhill found poor text comprehenders to show more difficulties with text-connecting inferences than skilled text comprehenders and than younger children matched on reading comprehension. Cain and Oakhill conclude from these results that the inability to make inferences at least partly causes poor reading comprehension. On the gap-filling inferences though, poor comprehenders scored lower than skilled comprehenders, but not lower than the group matched on reading comprehension. The authors suggest that the ability to make gap-filling inferences only develops at a later age and that making these inferences is therefore impossible for the younger reading comprehension matched children. In another study, Oakhill and Cain (1998) found skilled text comprehenders to make more inferences than poor comprehenders. Furthermore, they found the failure to answer inference questions to be caused by a failure to integrate information. Children do recall the relevant information from the text, but they fail to integrate this with their relevant background knowledge. The ability to make inferences has – as far as we know – not been investigated in deaf children, but it is reasonable to expect this ability to play a role in their reading comprehension difficulties.

Because – as the foregoing suggests – many subskills have been suggested to influence reading comprehension, one may expect factor analyses over reading comprehension tests that vary in the nature of their texts and of the questions posed about those texts, to show factors representing these subskills. However, Rost (1989), Rost, Czeschlick, and van der Kooij (1986), and Zwick (1987) found only one factor in a battery of reading comprehension test scores. This factor can be described as general reading comprehension. In a Dutch study, Boland and Mommers (1986) also concluded that one important factor determined the performance on a series of reading measures. It is not an uncommon finding that the greater part of the variance in several language measures is explained by one single general factor, even leading Oller (1976; but see van Bon, 1992) to propose his unitary competence hypothesis. That a single general factor is found with normally developing children, however, does not preclude that the different measures are based on different underlying competences. As Carroll (1993) argued, the unitary factor may depend “… on the degree to which an individual has, on the whole, acquired the many thousands of competences and response capabilities associated with that individual’s native language, or with a second language. All these competences tend to be learned together, pari passu, and in somewhat the same order by all individuals” (p. 191). Van Bon (1992) stated that, even if one general factor is found, this factor does not account for all of the covariance between measures nor for all the reliable variance within a measure, which indicates the presence of underlying competences. If unidimensionality of reading comprehension measures would be characteristic for normally hearing children, a topic to be verified in this study, this unidimensionality then might give way to multidimensionality in deaf children, who may be expected to show more idiosyncratic developments.

In order to verify these expectations, a sequence of factor analytic studies will be performed. The first step in these analyses will be to find out whether reading comprehension measures can be grouped according to an interpretable structure of component skills, for instance in terms of the three levels distinction discussed above, and whether this structure is different for deaf and hearing children. The next step will be to investigate whether deaf children score lower on specific rather than on all skills.

The comprehension measures to be used in our analyses are the four-choice items making up the reading comprehension tests used by Wauters et al. (in press) that showed a comprehension score discrepancy between deaf and hearing children. Restricting the analyses to the dichotomous item scores might conceal an underlying difference, namely in the way in which children decide between the response alternatives of these multiple-choice items. Therefore, additional distractor analyses will be done on the specific answers to see whether, when selecting an incorrect answer, deaf children and hearing children differ in their choice of alternatives and whether this is related to specific aspects of the items. Finally, the item scores will be related to the MOA of the test items to examine the power of MOA in explaining reading comprehension item difficulty for deaf and hearing children.

Method

Participants

The present study used the reading comprehension data of 253 deaf children (127 boys, 126 girls), aged between 7;11 and 20;1 years (mean age = 14;2 years), that were collected in a study by Wauters et al. (2003). The mean hearing loss of the participants was 105 dB, ranging from 80 to 130 dB. Their mean IQ was 100, ranging from 65 to 144. Of these participants, 17 were in schools for hard-of-hearing children, 30 were mainstreamed in hearing education, and 206 were in schools for the deaf.

Reading comprehension data for hearing children in primary education were obtained from the norming sample of the reading comprehension tests, collected by Aarnoutse.

Item response data were available for 1660 second graders, 2672 third graders, 2753 fourth graders, 2843 fifth graders, and 2925 sixth graders.

Materials

Reading comprehension in the deaf and hearing participants was measured using the Reading Comprehension Tests (*Begrijpend Leestests;* Aarnoutse, 1996) commonly used in the Netherlands with hearing children in Grades 2 to 6. Each grade has a different test consisting of 9 to 13 reading texts and 30 to 36 multiple-choice questions with four response alternatives each. The raw score on each test is the number of questions answered correctly. All tests are reported by Aarnoutse (1996) to have a reliability varying from .83 to .85.

For the purpose of the present study, all items of the Reading Comprehension Tests were classified in the following categories: vocabulary item, reference item, inference item, or item that requires understanding of the main idea of the text. Within the inference category, we further distinguished text-connecting inferences and gap-filling inferences (cf. Cain and Oakhill, 1999). Table 1 shows the number of items in the different categories for each grade level. Classification was done by two of the authors of this article, independently of each other. They agreed upon 90% of their classifications and Cohen's kappa showed an interrater reliability of .91 ($p < .001$). The remaining 10% of the items were classified after mutual agreement was reached.

Table 1. Number of items in each classification category for each comprehension test level.

Category	Test level Grade 2	Test level Grade 3	Test level Grade 4	Test level Grade 5	Test level Grade 6
Vocabulary	11	6	2	4	12
Reference	10	2	0	0	0
Main idea	8	8	9	6	4
Text-connecting inference	2	10	11	24	15
Gap-filling inference	5	4	8	2	1
Total	36	30	30	36	32

MOA ratings were collected for all nouns, verbs, and adjectives in the test items of the reading comprehension tests, that is, in the questions and response alternatives. This selection procedure resulted in a word pool of 731 lemmas in total. For 263 of these 731 lemmas, MOA ratings were already available from a previous study by Wauters et al. (2003) and an unpublished study by a graduate student (Geerdink, 2002). In the present study, the remaining 468 lemmas were rated by 20 student volunteers enrolled in third year courses in Philosophy of Education at the University of Nijmegen, The Netherlands, and by 9 PhD-students from the department of Special Education at the same university. As in a previous study on MOA (Wauters et al., 2003), words were rated on a 5-point scale, with 1 indicating acquisition through perception and 5 indicating acquisition through linguistic information. To control for order effects, the 468 words were printed in four random orders that were equally divided over the raters. For each of the 468 lemmas a mean MOA value was calculated over the 29 participants. Including the ratings from previous studies, ratings were available for all 731 lemmas. For some lemmas, an MOA value was available from more than one study. For these lemmas, a weighted mean was calculated. For each item in the reading comprehension tests, an MOA value was calculated by averaging over all tokens in an item.

Procedure

The hearing participants in the norming sample had completed the Reading Comprehension Test for the grade they were in. For the deaf participants, judgments by the individual teachers were used to determine the appropriate Reading Comprehension Test for each participant. If a child scored lower than the first decile for the original hearing norm group on the selected test, the next lower test level was also administered. Similarly, if a child scored above the eighth decile for the original hearing norm group, the next higher test level was administered. The test that was taken last was used in the analyses. As a result, of the 253 deaf children tested, 93 of them were tested at a second grade level, 71 at third grade level, 36 at fourth grade, 26 at seventh grade and 27 were tested at an eighth grade level. Because deaf children's reading comprehension level is often not in accordance with their age, the mean age of deaf participants taking a test of a certain level was higher than of the hearing participants taking that test. Table 2 shows the mean age and the age range by test level for the deaf participants and the mean age by test level for the hearing participants. Table 3 shows the mean raw scores for the deaf and hearing participants taking the successive test levels. At both the second and third grade level, the deaf participants scored lower than the hearing participants ($t(1751) = -5.39$, $p < .001$; $t(2741) = -3.46$, $p < .01$). At fourth and fifth grade level, deaf and hearing participants do not differ ($t(2787) = -1.13$, $p > .05$; $t(2867) = .006$, $p > .05$). At sixth grade level, the deaf participants outperform the hearing participants ($t(2950) = 2.82$, $p < .05$). In interpreting these results, it should be noted that the deaf and hearing participants are compared by test level, not by age. Therefore, one cannot conclude from these results that deaf and hearing children do not differ in reading comprehension.

All tests were administered by the teacher in the classroom. In the case of deaf students in mainstream education, the Reading Comprehension Test was administered individually by the student's itinerant teacher.

Table 2. Mean age (in years and months) for the deaf and hearing participants by level of test taken.

Test level	*M* deaf	*sd*	Minimum	Maximum	*M* hearing
2	12;10	2;11	7;9	18;9	7;6
3	14;6	2;1	7;10	20;1	8;6
4	14;10	2;4	10;0	20;1	9;6
5	15;10	2;3	10;11	18;7	10;6
6	15;4	2;2	11;11	18;11	11;6

Table 3. Raw scores on the reading comprehension tests (by test level) by deaf and hearing participants.

Test level	Deaf			Hearing		
	N	*M*	*sd*	*N*	*M*	*sd*
2	93	17.39	7.25	1660	21.67	7.45
3	71	15.41	4.73	2672	18.07	6.45
4	36	18.77	6.22	2753	19.84	5.58
5	26	24.46	4.06	2843	24.45	6.02
6	27	24.55	6.36	2925	21.33	5.90

Results

Three kinds of analyses were done to find out whether reading comprehension performance on the Reading Comprehension Tests can be ascribed to certain item characteristics and whether these are the same or different for deaf and hearing children. First, the results of factor analyses over dichotomous item scores will be described. Second, the results of distractor analyses that examined whether deaf and hearing children differ in their choice of alternatives, will be discussed. Third, analyses will focus on the role of MOA in deaf and hearing students' item scores and will control for word frequency and item category.

Factor analyses

Because the data consisted of dichotomous variables, tetrachoric correlations were used. Confirmatory and exploratory factor analyses were done using the Mplus program by Muthén and Muthén (2001). In the case of multiple factor solutions, promax rotations were done. The results will be discussed for hearing and deaf participants separately.

Hearing participants

Factor analytic studies on grammatical proficiency showed language measures in this domain to be characterized by one general factor only (Oller, 1976; Rost, 1989; van Bon, 1992; Zwick, 1987). Therefore, a confirmatory factor analysis was done to test whether a one-factor model is appropriate to describe the reading comprehension performance of the hearing participants. Table 4 shows the goodness-of-fit measures for a one-factor solution in each grade. For all grades, the root mean square error of approximation shows the one-factor model to fit adequately. The other fit measures also point in this direction, indicating that reading comprehension is indeed unidimensional. The one-factor model explained 30% of the variance in Grades 2 and 3, and 26, 22, and 25% respectively in Grades 4, 5, and 6. No group factors were found to explain the remaining percentage of the variance, which leaves much item variance unexplained.

Table 4. Goodness-of-fit measures of the one-factorial models for the hearing participants.

Grade	χ^2	*df*	p^a	CFI^b	TLI^c	$RMSEA^d$	$SRMR^e$
2	735.12	392	.000	.972	.986	.023	.042
3	1197.17	320	.000	.947	.974	.032	.043
4	3162.42	295	.000	.798	.877	.059	.071
5	887.74	450	.000	.966	.979	.019	.038
6	880.53	369	.000	.965	.979	.022	.037

[a] Goodness of fit when $p > .05$, [b] Goodness of fit when $CFI > .90$, [c] Goodness of fit when $TLI > .90$, [d] Goodness of fit when $RMSEA < .08$, [e] Goodness of fit when $SRMR < .05$

Deaf participants

For the deaf participants, factor analyses were only done for the data of the tests for Grades 2 to 4, because for the Grade 5 and 6 tests the number of variables exceeded the number of deaf participants. A confirmatory factor analysis was done to test whether for the deaf participants, reading comprehension performance can also be attributed to one general factor. A one-factor model explained 28, 21, and 33% of the variance for the items from the tests for Grades 2, 3, and 4 respectively. The goodness-of-fit measures in Table 5 show that at third and fourth grade level, the root mean square error of approximation is not sufficiently low to conclude that the one-factor model adequately describes the common variance in the reading comprehension process. Exploratory analyses were done for the items from the tests for Grades 2 to 4 to find out whether reading comprehension performance could be characterized by more than one factor. At second grade level, 12 factors had an Eigenvalue over 1. At third and fourth grade level, 11 factors had an Eigenvalue over 1 (see Table 6). In all three grades, the drop in the scree plot suggests the presence of two factors. At second grade level, the rotated two-factor solution explained 33% of the variance, with 14 items loading on the first factor and 10 on the second factor. However, these two factors could not be interpreted in terms of the a priori categories (see Materials). At third grade level, the rotated two-factor solutions show that 11 items loaded on the first factor and 9 on the second factor, together explaining 32% of the variance. These two factors again could not be interpreted in terms of the a priori categories. At fourth grade level, 14 items loaded on the first factor and 11 loaded on the second factor, together explaining 44% of the variance. Interpretation of these two factors in terms of the a priori categories was again impossible. In all three cases the factors appeared to be defined by rather heterogeneous collections of items.

Table 5. Goodness-of-fit measures of the one-factorial models for the deaf participants.

Grade	χ^2	*df*	p^a	CFI^b	TLI^c	$RMSEA^d$	$SRMR^e$
2	79.97	70	.195	.957	.962	.039	.137
3	80.20	48	.002	.704	.710	.097	.202
4	30.33	24	.174	.906	.913	.086	.225

[a] Goodness of fit when $p > .05$, [b] Goodness of fit when $CFI > .90$, [c] Goodness of fit when $TLI > .90$, [d] Goodness of fit when $RMSEA < .08$, [e] Goodness of fit when $SRMR < .05$

Table 6. Eigenvalues > 1 in Grades 2 to 4 for the deaf participants.

Factor	Grade 2	Grade 3	Grade 4
1	10.766	7.000	10.464
2	2.769	3.713	3.996
3	2.360	2.819	3.273
4	2.117	2.660	2.909
5	2.044	2.366	2.427
6	1.914	2.189	1.896
7	1.796	1.919	1.641
8	1.654	1.664	1.407
9	1.421	1.309	1.283
10	1.358	1.190	1.159
11	1.236	1.102	1.148
12	1.036		

Because the two-factor solutions did not show interpretable patterns of item loadings and the one-factor solution was not adequate to describe deaf students' reading comprehension performance either, we cannot draw conclusions regarding the factor structure that underlies deaf participants' item responses – except at second grade level where a one-factor model was adequate. It is possible, however, that a general factor does underlie the reading comprehension process, but that the heterogeneity of the group of deaf participants prevents the factor analyses from showing this factor. Therefore, confirmatory factor analyses were done to examine whether the one-factor models for the hearing participants also applied to the deaf participants. In these analyses, the factor loadings found for the hearing participants were used to specify the models for the deaf participants. Results showed that for the tests for Grades 2 and 4, the model found for the hearing participants was also adequate for the deaf participants (Grade 2: $\chi^2(67) = 94.73$, $p = .015$; CFI = .879; TLI = .888; RMSEA = .067; SRMR = .174, Grade 4: $\chi^2(23) = 27.517$, $p = .235$; CFI = .933; TLI = .936; RMSEA = .074; SRMR = .260). However, for the Grade 3 test, confirmatory factor analyses showed that the model for the hearing participants was not applicable to the data for the deaf participants ($\chi^2(47) = 94.32$, $p = .0001$; CFI = .565; TLI = .565; RMSEA = .119; SRMR = .235). This indicates that on the test for Grade 3, deaf participants do not show the same structure as hearing third graders in answering the test items.

Differences between item categories

The factor analyses studied whether scores on the reading comprehension tests could be classified in different factors and whether these factors were related to the categories in which we classified the items of the tests. No specific factor structure was found. Supplementary analyses, testing the influence of the item categories on the item scores, may shed more light on the structure of the reading comprehension tests. Non-parametric Kruskall-Wallis tests were done to measure the influence of item category on p-values (proportion of correct answers to an item) for deaf and hearing participants and on the difference in p-value between deaf and hearing participants. At all test levels, no influence of item category on the p-values of deaf and hearing participants was found (all $p > .05$). Also, no influence on the difference in p-value between deaf and hearing participants was found (all $p > .05$).

Distractor analyses

Chi-square tests were done to examine whether, when giving an incorrect answer, deaf children choose different distractors than hearing children in the multiple choice reading comprehension test. These analyses were done for the tests for Grades 2 and 3, because for the higher grade levels the number of deaf participants was too low to make a fair comparison.

On the test for second grade, deaf and hearing students differ in the distribution of their choices over the three incorrect response alternatives on 15 of the 36 items (see Table 7). Differences occurred mainly on the vocabulary and reference items. On nine of these items the deaf participants score lower than the hearing participants. For the other six items, no difference in percentage of correct answers was found between deaf and hearing participants. Of the items on which deaf and hearing participants differed in their choice of alternatives, all items identified as vocabulary items were more difficult for the deaf than for the hearing participants. For the other categories, no systematic difference of preference was found. This outcome suggests that a difference in vocabulary may lie at the origin of deaf students' reading comprehension problems.

On the test for third grade, the distribution over the incorrect answers is different for deaf and hearing participants for 10 of the 30 items. Deaf and hearing participants differed mainly on the inference items (see Table 7). Seven of these items were more difficult for the deaf than for the hearing participants. On the other three items, no difference in percentage of correct answers occurred between the deaf and hearing participants. Differences in score between deaf and hearing participants were not related to specific item categories.

Table 7. Items on which deaf and hearing participants differ in their choice of alternatives (in percentage of items in a category).

Category	Grade 2	Grade 3
Vocabulary	45%	17%
Reference	60%	50%[a]
Main idea	12.5%	37.5%
Text-connecting inference	100%[a]	30%
Gap-filling inference	20%	50%

[a] Based on two items.

Concluding, the distractor analyses did not provide a clear-cut solution. At second grade level, deaf and hearing participants differed in their choice of alternatives mainly on the vocabulary and reference items. At third grade level, they differed mainly on the inference items.

Mode of acquisition

Before discussing the influence of MOA on the reading comprehension scores, analyses on the reliability of MOA ratings are presented. A principal axis factor analysis with the participants as variables and the words as cases was done to examine which factors influence adults' decision of how a word meaning is acquired. Two factors with Eigenvalues over 1 were found of which the first factor explained 57% of the variance and the second factor only an additional 7%. Factor loadings on the first factor were high for all raters (mean = .74), indicating that judges strongly agree on how word meanings are learned. Interrater agreement (McGraw & Wong, 1996) was also assessed through a Two-way Random Effect Model (Absolute Agreement Definition) intraclass correlation coefficient (ICC). As in a previous study by Wauters et al. (2003), a high ICC (.96) was found, indicating a high absolute agreement between the rating patterns of the different participants.

The change over grades in the MOA of words in the reading comprehension tests underscores the validity of MOA, because it is in line with expectations (cf. Wauters et al., 2003). Figure 1 shows the mean MOA for each grade. A low mean MOA indicates that words are acquired mainly through perception, while a high mean MOA indicates that words are acquired mainly through linguistic information. Figure 2 shows the percentage of words rated in the different classes of the MOA rating scale for the different grades. As in previous research (Wauters et al., 2003), the mean MOA of words in texts and the proportion of words in the different rating scale classes increase over grades. In the Grade 2 test, items consist mainly of words that are rated as acquired mainly through perception. In the Grade 3 and 4 tests, items mainly contain words that are rated as acquired through a combination of perceptual and linguistic information. In the Grade 5 and 6 tests, items consist of words that are learned mainly through linguistic information.

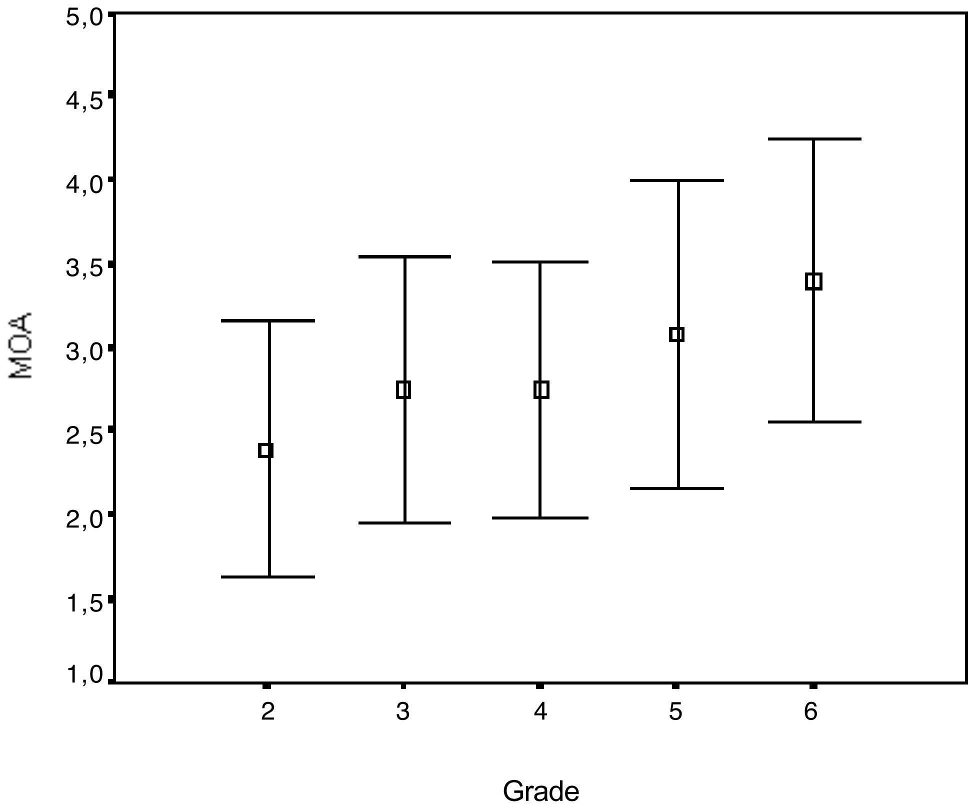

Figure 1. *Mean MOA and 1 SD range for the words in the test items.*

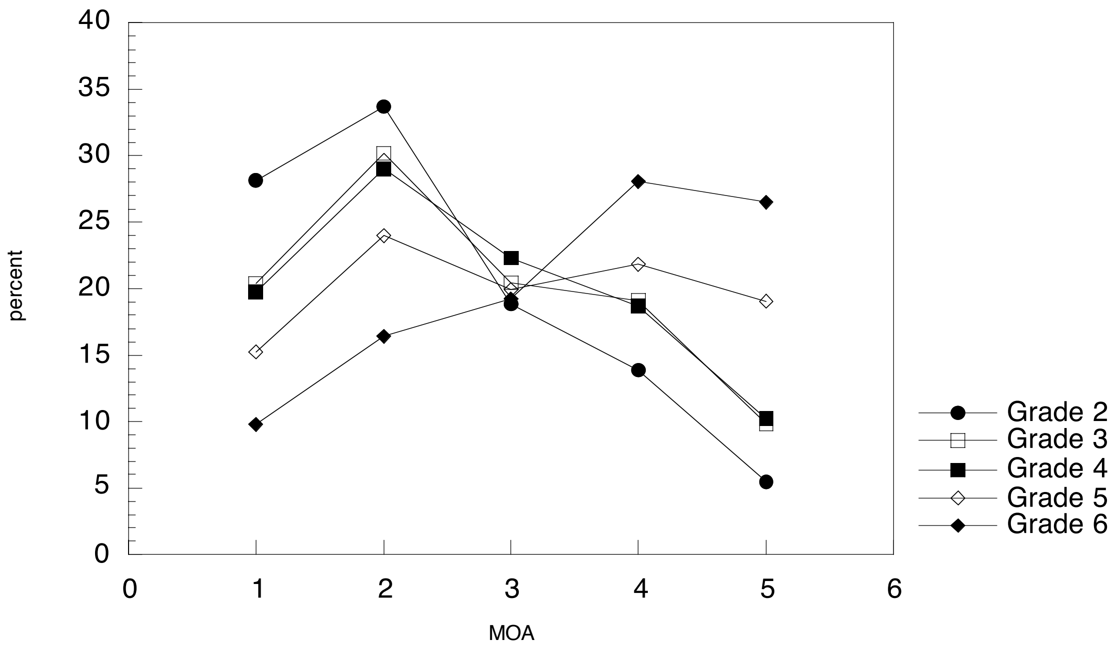

Figure 2. *The percentages of MOA ratings for each grade level.*

The MOA ratings by the adult participants were used in studying the influence of MOA on the scores of deaf and hearing students at the different levels of the reading comprehension test. Correlations were calculated between the MOA ratings of the items and their p-values (the proportion of correct answers to an item) for deaf and hearing students. In addition, correlations were calculated between the MOA of an item and the difference between the p-values for deaf and hearing students. Each item consists of a question and four response alternatives. As a measure of the MOA of an item, the mean MOA rating over the words in that item was calculated. Another measure of the MOA of an item is the minimum MOA rating occurring in the item. Each word in an item has a mean MOA value. One of the words has the lowest mean MOA value, which is the minimum MOA in an item. The minimum MOA was included, because it functions as some kind of threshold measure. If the lowest occurring MOA value is too high, comprehension will fail. Because minimum alone is not sufficient, we also included the mean MOA. A low minimum does not guarantee a low mean.

Table 8. Correlations between MOA and p-values for the different grades.

		p-value deaf	p-value hearing	difference deaf-hearing
Grade 2	Mean MOA	-.193	-.186	-.087
	Minimum MOA	.127	$.355^{*}$	-.189
Grade 3	Mean MOA	$-.526^{**}$	$-.503^{**}$	$-.385^{*}$
	Minimum MOA	-.147	-.082	-.011
Grade 4	Mean MOA	-.107	-.196	-.058
	Minimum MOA	$-.443^{*}$	$-.542^{**}$	-.042
Grade 5	Mean MOA	$-.350^{*}$	-.233	-.182
	Minimum MOA	-.031	-.022	-.172
Grade 6	Mean MOA	-.086	.001	-.107
	Minimum MOA	.101	.304	$-.390^{*}$

* $p < .05$, ** $p < .01$

Correlations between these MOA measures and the p-values are given in Table 8. Before discussing these correlations, it is important to note that deaf and hearing participants taking the tests for third and fourth grade level did not differ in their reading comprehension scores. At second and third grade level, the deaf participants scored lower than the hearing participants and at sixth grade level, the deaf participants scored higher than the hearing participants. Of course, we compared students who took the same test level and, as Table 2 showed, the deaf participants were older than the hearing participants.

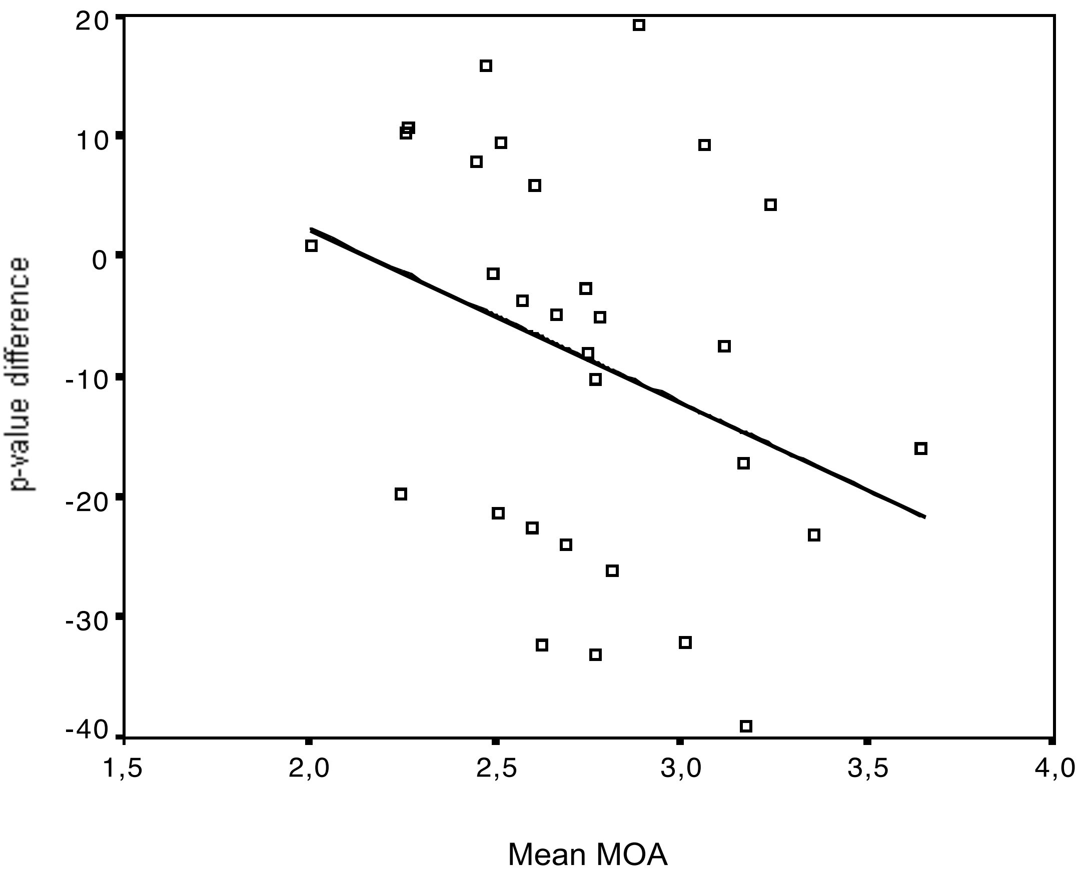

Figure 3. *Relation between MOA and the difference in p-value between deaf and hearing children for Grade 3.*

Correlations between MOA and the p-values show that, especially for the tests for Grades 3 and 4, MOA influences deaf and hearing students' reading comprehension. At third grade level, a higher mean MOA goes together with lower p-values, indicating that deaf and hearing students give fewer correct answers when the mean MOA of an item increases. At fourth grade level, p-values decrease when the minimum MOA value of an item increases. At fifth grade level, MOA correlates only with deaf students' reading comprehension and not with hearing students' reading comprehension. Table 8 further shows that at third and sixth grade level, MOA correlates with the difference in p-values between deaf and hearing students. In third grade, the difference between deaf and hearing students increases when MOA increases (see Figure 3). At sixth grade level, deaf students score higher than hearing students, but this difference decreases when the minimum MOA increases (see Figure 4). In summary, MOA influences reading comprehension for both deaf and hearing children at third and fourth grade level, and at third grade even explains the difference between the two groups. At the fifth and sixth grade level, MOA only influences reading comprehension for the deaf children.

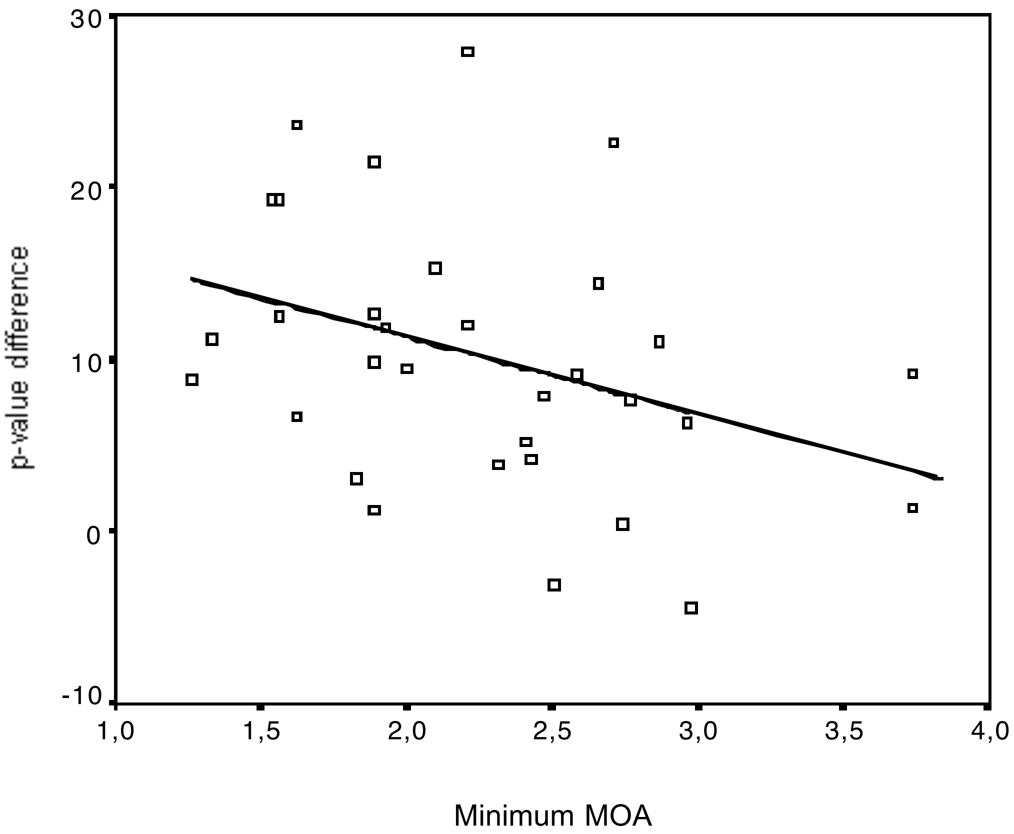

Figure 4. *Relation between MOA and the difference in p-value between deaf and hearing children for Grade 6.*

The correlation between MOA and p-value of an item could be the by-product of the influence of word frequency. Table 9 shows the mean word frequencies for the different grade levels, calculated using the Celex database (1990). No significant correlations were found between word frequency and p-values for deaf or hearing students. No significant correlations were found either between MOA and word frequency, except for the Grade 4 test where higher MOA corresponded to lower frequency ($r = -.37$, $p = .044$).

Table 9. Word frequencies (per million) for the different grades.

Grade	*N*	*M*	*sd*
2	36	318	184
3	30	309	260
4	30	361	218
5	36	288	204
6	32	225	158

Note. Frequency data were derived from CELEX, a lexical database for Dutch words (CELEX Dutch database, 1990).

Discussion

The present study examined whether mode of acquisition and other specific item characteristics influence reading comprehension in deaf students as measured with a standardized multiple choice reading comprehension test.

Factor analyses studied whether a difference in dimensionality can be found in deaf and hearing children's scores on multiple-choice reading comprehension items and whether this dimensionality could be interpreted as a classification of items that are specifically easy or difficult for deaf and hearing children. For the hearing participants, the factor analyses showed that in Grades 2 to 6, reading comprehension could be ascribed to one general reading comprehension factor. This factor explains between 22% and 30% of the variance in reading comprehension. For the deaf participants, we expected to find more than one dimension because they have been found to show difficulties in more than one aspect of reading comprehension. However, the results do not unambiguously point in that direction. Factor analysis for the Grade 2 test showed a one-factorial model to adequately describe deaf students' reading comprehension process. For the Grade 3 and 4 tests, a one-factor model did not fit and the two-factor solutions seemed to be spurious. These results indicate that it is hard to specify and differentially characterize deaf students' reading comprehension in terms of dimensionality. However, for the Grade 2 and 4 tests, the one-factor model found for hearing participants is also applicable to the reading process of the deaf participants. For both deaf and hearing participants, not all variance that can be assumed to be reliable is explained by the one general factor found in the factor analysis. As no group factors are found to explain the remaining variance, it must be assumed that a large proportion of the variance is item specific. Obviously, the reading comprehension tests involve many specific skills and forms of knowledge that cannot be grouped in factors. Explicit testing of an a priori classification of items, with respect to their inherent measure of reading comprehension components, did not point to such factors as determinants of item difficulty nor of differences in performance between deaf and hearing readers.

To reduce the chance that underlying differences are overlooked, distractor analyses were done to study whether specific test items lead to a different choice of alternatives for deaf and hearing students. The results from the distractor analyses show that on some items, deaf participants prefer a different distractor than hearing participants when giving an incorrect answer. In second grade, a difference especially occurs on the vocabulary and reference items. In third grade, the difference between deaf and hearing participants occurs mostly on the inference items. Unfortunately, these results are not compelling enough to designate specific factors in reading comprehension.

Overall, the results of the present study point to one general factor in the reading comprehension process for both deaf and hearing children. The supposedly more idiosyncratic development of deaf children does not drastically affect the dimensionality in their reading comprehension process. Moreover, the model for hearing children is presumably also adequate to describe the reading comprehension process of deaf children, indicating that deaf children do not distinctly deviate from hearing children in the process of taking the reading comprehension test. Yet, they do score considerably lower than hearing children on the reading comprehension test studied here (Wauters et al., in press). The result that one general factor influences reading comprehension does not preclude the possibility that differences in score between deaf and hearing children are caused by item differences in MOA. Instead of differences in the dimensionality of reading, differences in MOA may explain the performance gap between deaf and hearing children. The present study confirmed findings from previous research (Wauters et al., 2003), in which the mean MOA of words in texts was found to increase over grades. Further, the proportion of words in the different classes of the MOA rating scale changed over the grade levels of the test. Over the grade levels, the proportion of mainly perceptually acquired words in the test items decreases and the proportion of mainly linguistically acquired words increases.

Results on the role of MOA showed that at third and fourth grade level, MOA influences item scores in deaf and hearing students. The percentage of correct answers decreases as the mean or minimum MOA in an item increases. At third grade level, MOA is related to the difference between deaf and hearing students. Deaf students score lower than hearing students and when the mean MOA of items increases, the difference between deaf and hearing students increases. At fifth grade level, MOA influences reading comprehension for deaf students, but not for hearing students. At sixth grade level, MOA is only related to the difference in score between deaf and hearing students. Deaf students score higher than hearing students, but this difference decreases when the minimum MOA in an item increases. Interestingly, MOA starts to influence reading comprehension at third grade level, when a shift occurs in the test items from containing words acquired mainly through perception to words acquired through a combination of perceptual and linguistic information. At fourth and fifth grade level, no differences in score occur between deaf and hearing students, but MOA does influence item scores. In fourth grade, MOA influences item scores of both deaf and hearing students, indicating that for both groups words that are rated as acquired mainly through linguistic information are difficult to understand. In fifth grade, MOA only influences deaf students' item scores, indicating that words that are rated as acquired mainly through linguistic information are more difficult for deaf than for hearing students. However, this difficulty does not have repercussions for deaf students' overall score on the test.

As in previous research (Wauters et al., 2003; Wauters, Tellings, et al., 2004), the present study found MOA to be a viable construct that influences reading comprehension. Of all the analyses in the present study, MOA was the only factor to noticeably influence scores on the items in the reading comprehension test. Test items from the different test levels are found to show different mean MOA values and different distributions of MOA ratings. Moreover, deaf and hearing students' scores on the items and the difference between deaf and hearing students changed when the MOA value of an item changed. Obviously, the relatively new construct MOA is a relevant factor in reading comprehension and in explaining deaf students' reading comprehension difficulties.

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General conclusions and discussion

In the present thesis, an attempt was made to unravel which factors play a major role in deaf children's reading comprehension. Reading comprehension was studied in a large part of the deaf school-aged population in the Netherlands. This thesis specifically studied the role of two factors in the reading comprehension process: word identification and mode of acquisition (MOA). In this final chapter, the results of the studies described in this thesis will be reviewed and discussed. The discussion will be concluded with some implications for theory and practice.

The present study was the first to investigate reading comprehension in a large group of deaf children in the Netherlands and found reading comprehension scores to be shockingly low. In Chapter 2, 7 to 20-year-old deaf participants are found to show an average reading comprehension score at the level of first grade for hearing children. This result corresponds to results of earlier studies in the United States and the United Kingdom where deaf children were also found to perform at a lower level than hearing children. However, in those studies the average score was not as low as for the Dutch deaf children but was comparable to the third or fourth grade level for hearing children. It is difficult to explain this difference in results, given that both the language and the educational system of these countries differ. Also, different tests have been used in these studies.

Chapter 2 further showed that the average word identification scores for the deaf children at the various instructional ages do not differ much from those of the hearing children, indicating that the low reading comprehension scores cannot be explained by word identification. Word identification and reading comprehension did correlate, but reading comprehension scores would still be low even if word identification scores were at an age-appropriate level. These findings correspond to the results of Burden and Campbell (1994) and Merrills, Wood, and Underwood (1994) who found that deaf children's reading comprehension problems could not be completely ascribed to word identification problems.

The second factor in reading comprehension studied in this thesis was mode of acquisition, i.e., whether the meaning of a word is learned through perceptual information or rather through linguistic information. Chapter 3 showed that mode of acquisition can be reliably measured through ratings by adults on a 5-point scale, going from mainly perceptual (low) to mainly linguistic (high). Adults show strong agreement in their MOA ratings of words. Apart from being reliably measurable, MOA can be distinguished from the word characteristics concreteness and imageability. The fact that adults agree on their judgments of how word meanings are learned and that it can be distinguished from concreteness and imageability, indicates that MOA is a feasible construct.

The adult ratings were used to determine whether texts in the successive grades of elementary school differ in the MOA of the words used. Results showed a gradual increase of the mean MOA of word meanings in texts over the grades of elementary school. Texts in the lower grades contain a higher percentage of word meanings that are rated as being learned through perceptual information, while texts in the higher grades – from fourth grade onward – contain a higher percentage of words that are judged as being learned mainly through linguistic information. The higher proportion of perceptually learned words in the lower grades can be explained by the fact that in these grades simple texts are used because reading instruction focuses more on decoding than on providing information. Texts will consist of words that are most certainly known by the children and usually these will be words that have been learned through perceptual information. In the higher grades, more complex texts are used focusing more on providing information, and sometimes on learning new words.

After having established that MOA is a viable construct and that words used in texts in the successive grades of elementary school differ in MOA, the role of MOA in reading comprehension can be studied. Chapter 4 shows that mode of acquisition plays a role in sentence comprehension, not only for deaf but also for hearing children. In a self-paced reading task, reading times for both groups were longer on linguistic words than on perceptual words. In addition, sentence comprehension scores were lower for sentences containing a linguistic target word than for sentences with a perceptual target word. We expected deaf children to perform at a level similar to hearing children on perceptual words, but to read more slowly and have a lower comprehension score on linguistic words. However, no differences in reading time were found between deaf and hearing children for either type of word, whereas for both types the comprehension scores were lower for deaf than for hearing children, indicating that comprehension of both perceptual and linguistic items was difficult for deaf children. Reading times decreased over age for the hearing but not for the deaf children. Scores on the comprehension questions increased over age for both groups. Furthermore, the difference between the perceptual and the linguistic condition – in both reading time and score – decreased with age for the hearing but not for the deaf children. This difference may be partly caused by the fact that the hearing children showed a ceiling effect for the perceptual words.

Chapter 5 studied the role of MOA in reading comprehension by contrasting it to other possible determinants of the reading comprehension process. The results of this chapter confirm findings from Chapter 3 in that MOA was again reliably measurable and test items of the successive grade levels differed in the MOA of the words used. Furthermore, of the determinants that were studied, only MOA significantly influenced scores on the multiple choice reading comprehension tests. Factor analyses found that for both deaf and hearing children only one factor is involved in the reading comprehension item scores. In Grades 2 and 4, the one-factor model for hearing children is adequate to describe the reading comprehension performance of deaf children. No group factors were found pointing to particular item characteristics that influence reading comprehension. Subsequent analyses of the role of the different item categories failed to show significant effects on deaf and hearing children's reading comprehension scores. Specific analyses on the effects of MOA, however, found that MOA correlates with the proportion of items that are answered correctly. At second grade level MOA did not significantly correlate with the item scores. This finding is in line with the finding that, at this level, reading materials predominantly contain word meanings that are acquired mainly through perception. For deaf children, high MOA values of the words in the test items are related to a lower proportion of correct answers at all grade levels, from third grade on. For hearing children, high MOA is only related to a lower proportion of correct answers at third and fourth grade level.

This summary of research findings encourages us to propose a tentative theory to explain the reading comprehension differences between deaf and hearing children. Reading comprehension at least requires word identification and knowledge of word meanings.

However, word identification does not explain the reading comprehension differences between deaf and hearing children. Therefore, we turn to the second central component in reading comprehension, knowledge of word meanings, and here our theory focuses on the mode of acquisition (MOA) of word meanings.

In studying MOA, we assume a distinction between perceptual and linguistic information in language acquisition, and we suppose that both contribute to our knowledge of word meanings. This is in line with the dual code theory as supported by Paivio (1986; 1991), in which two systems are thought to influence information processing: a verbal system and an image system. The verbal system processes linguistic information and generates speech, while the image system processes perceptual information (visual, auditory, etc.) about non-verbal objects or events. Of course, the orthographic unit [ball] or the spoken language unit /ball/ also constitute perceptual information (visual or auditory), but this is different from the perceptual information from a picture of a *ball* or an actual *ball*. The orthographic unit [ball] or the spoken language representation /ball/ will be processed as linguistic information, while the concept *ball* will be categorized as perceptual information about the world around us. Thus, the theory presented here presumes that knowledge of word meanings consists of two kinds of elements, derived from orthographic or spoken language units on the one hand, and perceptual information on the other.

Many word meanings are learned through verbal explanations. However, most word meanings are learned through a mix of perceptual and linguistic information. Estimates of the proportion of verbal and perceptual information used in acquiring word meanings were found to be consistent enough to hold on to our theoretical assumptions.
The distinction between linguistic and non-linguistic information remains present in our mental lexicon. For hearing children, the mental lexicon can be assumed to consist of spoken language units, orthographic units, and semantic units. The semantic units specify the meanings of words. A word's meaning consists of a complex of perceptual and linguistic elements. The linguistic elements are complex chains of labels, which, in their turn, can refer to concepts that are also complex combinations of perceptual and linguistic elements. For example, the meaning of *caravan* consists of both linguistic and perceptual elements. A child could learn the meaning of *caravan* entirely by seeing real caravans

and going on vacation with a caravan. But not all parents have a caravan and most children will learn the meaning of *caravan* by a combination of perceptual information and linguistic information. Someone will explain to the child that a caravan is a small house on wheels for vacation. Now, to understand this explanation the child must have acquired the word meanings *house*, *wheels,* and *vacation*, and these word meanings probably will also be learned through a combination of perceptual and linguistic information. The linguistic part of learning these latter words in its turn requires the knowledge of relevant words, for instance, *vacation* is *not-working or going to school* and is *doing fun things*. Now, it is reasonable to assume that learning a word meaning like *caravan* requires a different combination of linguistic and non-linguistic steps than learning the meaning of a word like *guru* or *grammar*. Thus, word meanings are acquired through more or less complex combinations of perceptual and linguistic steps. Through varying combinations of perceptual and linguistic information, children will first acquire word meanings that consist mainly of perceptual elements and as they grow older, they will learn word meanings that are more linguistic in nature. The distinction between perceptual and linguistic information remains present in the mental lexicon and functions in the reading process when reading words in sentences or texts and understanding the meaning of these words.

After the foundation for meaning acquisition is laid through perception and spoken language, reading starts to contribute to word meaning acquisition, and learning to read will soon shift to reading to learn (see also Chall, 1987): reading to learn about the world around us, but also reading to learn more word meanings. Reading itself contributes to the enrichment of the word meanings through expanding the linguistic elements and specifying and embedding the interrelations between elements. This enrichment enables the reading of more abstract texts, which again contributes to the meaning acquisition process.

Results of the studies in this thesis showed that texts and reading comprehension tests in elementary school are indeed constructed in accordance with the idea that the more perceptual words are learned first. In early reading development, simple sentences are used with words with low MOA ratings, indicating that these words are learned mainly through perceptual information. In the higher grades of elementary school, words used in texts and tests have higher MOA ratings, indicating acquisition mainly through linguistic information.

So far, we have discussed the situation for hearing children, but what happens when a child is deaf? We found deaf children to have much lower reading comprehension scores than hearing children, but this difference cannot be explained by difficulties in written word identification. Therefore, the theory presented here focuses on word meaning acquisition.

Differences in language input for deaf and hearing children make acquisition of word meanings different as well (Marschark, 2002; Musselman, 2000). Acquiring perceptual images of the world around us will not be different for deaf children (with the exception of auditory perception), but the connection of those images with linguistic labels will. From birth on, hearing children have access to spoken words and their language acquisition starts by imitating the sounds and associating the spoken words with the objects they refer to. This is not possible for deaf children, for the simple reason that they cannot hear spoken words. Therefore, the connection between the spoken word and the object will not be so easily made as by hearing children. Furthermore, acquiring more linguistic concepts will also be difficult, because – initially – these concepts are acquired in connections with linguistic labels of dominantly perceptually acquired concepts. Of course, deaf children who are raised with sign language in addition to spoken language will have the opportunity to make a connection between the sign and the referent. However, for deaf children of hearing parents (about 95% of the deaf children, Mitchell & Karchmer, 2004) sign language is not available at an early age because their parents have to learn that language first. Thus, this group will also acquire the connections between labels and referents more slowly and differently than hearing children. Still, the difference between orally educated and bilingually educated deaf children is important from our point of view, which we will illuminate in the following.

For orally educated deaf children, the mental lexicon will consist of the same units as for hearing children: spoken language units, though in a distorted form because they have to be derived from very little residual hearing and from speech reading; orthographic units; and semantic units. Reading difficulties in this group of deaf children can stem from various obstacles. First, the number of spoken language units may be less for them than for hearing children, because accessibility of these units depends on residual hearing and the quality of speech reading. Speech reading does not provide perfect mapping because many phonemes cannot be unambiguously read from the lips (Knoors, 2001; Harris & Beech, 1995). Second, and as a result of the first, the number of known word meanings may be less for these deaf children than for hearing children. Third, and as a consequence of the previous two, the contribution of linguistic elements to previously acquired word meanings will be smaller. Thus, many word meanings will be impoverished and, as a result, the contribution of reading to conceptual development will be smaller than for hearing children. Consequently, problems will arise when these deaf children have to read texts containing words with high MOA ratings.

For bilingually educated deaf children, the mental lexicon can be assumed to involve an additional unit: sign language units. For these deaf children, the linguistic information used in acquiring word meanings can consist of sign language units, spoken language units, and – at a later stage – orthographic units. However, the degree to which signs can be used depends on how early in the child's development the parents (and others in the child's environment) learn sign language. Because some time will pass before hearing parents have learned sign language, the sign vocabulary of deaf children will be smaller than the spoken word vocabulary of hearing children. Acquiring concepts that are more linguistic in nature depends on the available units (in sign language or spoken language). Assuming that sign language is the main language for this group of deaf children, acquiring the more linguistic concepts will depend mainly on the signs a child already knows. If much sign language is available (as will be the case for deaf children of deaf parents), bilingually educated deaf children should be able to acquire the more linguistic concepts. But if these deaf children know fewer signs than hearing children know spoken words, acquisition of linguistic concepts will be more difficult for them than it is for hearing children. This would cause difficulties in reading when texts contain many words with high MOA ratings. Furthermore, even if these children's knowledge of linguistic concepts is adequate in sign language, they may encounter difficulties in reading because written language strongly appeals to knowledge of spoken language (see also Mayer & Wells, 1996; Musselman, 2000). Written words evoke their spoken counterparts and the connected concepts. For bilingually educated deaf children, the conceptual knowledge related to spoken language units will be limited compared to the knowledge related to sign language units. In reading, these children will have to complete an extra step in order to access the 'sign system'. Further research should point out what exactly happens in the meaning acquisition process of bilingually educated deaf children and how this influences reading comprehension.

The theory, as presented here, encompasses more than we studied in the present thesis. Therefore, acceptance of the theory would be preliminary and further research should clarify how deaf children learn word meanings and how language modality influences this process. However, the studies in this thesis do provide some evidence for the ideas presented in our theory.

Results from Chapters 4 and 5 indicate that the influence of MOA on reading comprehension persists as deaf children grow older and as their reading comprehension improves. These results confirm the hypothesis that reading comprehension is hindered when texts (or tests) contain many words with a high MOA rating. Words with high MOA ratings increase reading times, and decrease comprehension scores of sentences in which these words occur. This is in line with the idea that the distinction between linguistic and non-linguistic information remains in function in the mental lexicon.

Results from Chapter 4 showed that for *hearing* children, the reading times for words with a low MOA decrease over instructional age. The same is true for words with a high MOA. Overall, reading times for the more linguistic words were longer than for words that are learned mainly through perception. Apart from a decrease in reading times for perceptual and linguistic words, the difference in reading time between the two also decreases over instructional age. Beyond fourth grade, reading times for the high-MOA words show a faster decrease than reading times for low-MOA words.

For *deaf* children (not differentiated by language modality), the results were somewhat different. They also show longer reading times for words with a high MOA than for words with a low MOA, but their reading times for words of both types do not decrease over instructional age. As a consequence, the difference in reading times between the words with low and high MOA values did not decrease over instructional age either.

As for the comprehension of the sentences, results show that – in line with our expectations – scores of the *hearing* children on words with a low MOA almost immediately reach a maximum level and hardly increase over instructional age. For the words with a high MOA, scores show a tremendous increase at the beginning of reading development and approach the maximum score at fourth grade with only a slight increase beyond that point.

The *deaf* children show an overall lower comprehension score than the hearing children on both words with low and words with high MOA ratings. Scores on words with low MOA ratings gradually increase over the years. However, comprehension scores on words with high MOA hardly increase up to an instructional age of five years and only at an instructional age of six years scores on these words become higher.

Results of Chapter 5 show that MOA also influences scores on the items of a multiple choice reading comprehension test. For *hearing* children, MOA influences the item scores at third and fourth grade level. Beyond fourth grade, the mean MOA of the words in the items no longer influences the item scores. This is in line with the finding in Chapter 4 where hearing children in fourth grade were found to know the meanings of most words with high MOA ratings. For the *deaf* children, MOA influences item scores up to the sixth grade test level. At third grade level, MOA also influences the difference in score between the deaf and hearing children. Again these results are in line with the results from Chapter 4 where MOA influenced deaf children's reading times and comprehension at all instructional ages.

These results support the theory presented here, but the evidence is not yet complete. The present thesis studied the influence of the MOA of words on reading comprehension using adult ratings of how children acquire word meanings. The process of how children acquire these word meanings was not studied and would be an interesting topic for further research. The MOA of words, as rated by adults, was found to influence reading comprehension. Further research should point out whether MOA still plays a role in reading comprehension when exact word meaning acquisition data are used.

In line with this suggestion, word meaning acquisition by deaf children and their conceptual development should be studied longitudinally. The present thesis found that reading materials in the successive grades of elementary school differ in the MOA of the occurring words, as rated by adults. Furthermore, for hearing children the influence of MOA was found to decrease over grades. For deaf children, MOA influences reading comprehension up till a later age. These results are based on data of different samples of children in the various grades. As a result of differing language backgrounds, the children in these samples will probably differ in their conceptual development. Sampling ‘errors’ may have attenuated the relations between variables (e.g., the actual and the rated MOA of a word). It is essential to study children for a longer period to determine the actual relations between variables and their role in developmental processes.

In studying the acquisition of word meanings in deaf children, it is also important to study the influence of language input. The present study did not differentiate between orally educated deaf children and deaf children educated with signs. The acquisition of word meanings may differ for these groups of deaf children. Further research should investigate the different acquisition processes for these children and the consequential differences in the mental lexicon. This would shed some light on the role of sign language in conceptual development.

Chapter 5 of this thesis studied the role of MOA on scores on the items of a reading comprehension test. The deaf and hearing children studied here differed in age, because comparisons were made between children who took the same test level. A comparison of deaf and hearing children of the same age taking the same test would be preferable. The present study showed the mean reading comprehension score of deaf children and adolescents to be at first grade level. At the lower reading comprehension levels, it may be possible to compose comparison groups of the same age, but this will be difficult for the higher reading comprehension levels. Nevertheless, comparing the role of MOA for deaf and hearing children matched on age and reading level would be valuable. However, because matching on age and reading level may result in a comparison group of good deaf readers and poor hearing readers, it would probably lead to biased results.

The results of this thesis have important implications for educational practice. Obviously, comprehension of words with predominantly linguistic meaning elements is difficult for deaf children. According to our theory, this difference in knowledge of linguistic word meanings between deaf and hearing children is caused by a difference in language input. Less language input for deaf children results in less available linguistic units in the mental lexicon (in spoken language or sign language units), which hinders acquisition of word meanings with strong linguistic elements. As we suggested before, a difference may also occur between orally and bilingually (or monolingual manually) educated deaf children because language input will differ. How exactly the acquisition of word meanings for both groups of deaf children takes place needs further investigation, but it is obvious that the language situation in which a child grows up influences the acquisition process. Linguistic experience is necessary to enable the child to enrich his or her concepts. Therefore, abundant language input is extremely important.

The present thesis demonstrated that MOA influences deaf children's reading comprehension. Texts containing a large proportion of words that are rated as being learned linguistically are difficult to understand for deaf children. To prevent these difficulties, attention should be given to the language input these children receive. From an early age on – in the most perfect situation, from birth on – word meanings have to be presented in the most accessible language for the child in order to expand conceptual knowledge. It is important that all children receive a broad range of linguistic and non-linguistic information in both explicit and implicit learning situations. It is essential to supply as many words as possible to enable the child to learn concepts with strong linguistic meaning elements. Which language is the most accessible will be different for each deaf child, but sign language may significantly contribute to the acquisition process, because this language is accessible for almost all deaf children.

In addition to abundantly supplying spoken words or signs, the written word should be introduced as soon as possible to facilitate the connection between the two modalities (written with spoken or signed). Through reading words, sentences, and texts, learning to read will develop into reading to learn.

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SUMMARY

This thesis studied reading comprehension in a large part of the deaf school-aged population in the Netherlands. More specifically, the role of two factors in the reading comprehension process was studied: word identification and mode of acquisition (MOA).

Chapter 2 shows the reading comprehension scores of deaf children in the Netherlands to be shockingly low. A large group of 7 to 20-year old deaf participants were found to show an average reading comprehension score at the level of first grade for hearing children. However, the average word identification scores for the deaf children at the various instructional ages (referring to the number of years of formal instruction) did not differ much from those of the hearing children, indicating that the low reading comprehension scores are not due to poor word identification. Moreover, it was calculated that reading comprehension scores would still be low even if word identification scores were at an age-appropriate level.

The second factor studied in this thesis was mode of acquisition. Mode of acquisition refers to the way in which children (or adults) acquire the meaning of a word. Roughly, the meaning of a word can be acquired through perception of the referents of the words, through linguistic information, or through a combination of both. Chapter 3 shows that mode of acquisition can be measured reliably through ratings by adults on a 5-point scale, going from mainly perceptual (low MOA) to mainly linguistic (high MOA). Moreover, the MOA of words thus established appears not to coincide with the similarly established word characteristics concreteness and imageability.

The adult MOA ratings were used to determine whether texts in the successive grades of elementary school differ in the MOA of the words used. Results showed a gradual increase of the mean MOA of word meanings in texts over the grades of elementary school. Furthermore, texts in the lower grades contain a higher percentage of word meanings that are rated as being learned through perceptual information, while texts in the higher grades – from fourth grade onward – contain a higher percentage of words that are judged as being learned mainly through linguistic information. The latter finding supports the hypothesis that part of the reading comprehension problems that deaf readers

have with texts for the higher grades is caused by the mode of acquisition of word meanings in those texts.

After having established that MOA is a viable construct and that words used in texts in the successive grades of elementary school differ in MOA, the role of MOA in reading comprehension was studied. Chapter 4 shows that mode of acquisition plays a role in sentence comprehension, not only for deaf but also for hearing children. In a self-paced reading task, reading times for both groups were longer on linguistic words than on perceptual words. In addition, sentence comprehension scores were lower for sentences containing a linguistic target word than for sentences with a perceptual target word. No differences in reading time were found between deaf and hearing children for either type of words, whereas for both types the comprehension scores were lower for deaf than for hearing children, indicating that comprehension of both perceptual and linguistic items was difficult for deaf children. Reading times decreased over age for the hearing but not for the deaf children. Scores on the comprehension questions increased over age for both groups. Furthermore, the difference between the perceptual and linguistic condition – in both reading time and score – decreased over age for the hearing but not for the deaf children. This difference may be partly caused by the fact that the hearing children showed a ceiling effect for the perceptual words.

Chapter 5 studied the role of MOA in reading comprehension by contrasting it to other possible determinants of the reading comprehension process such as vocabulary, syntax, and the ability to make inferences. The results of this chapter confirm findings from Chapter 3 in that MOA can be determined reliably and test items of the successive grade levels differed in the MOA of the words used. Furthermore, of the determinants that were studied, only MOA significantly influenced scores on the multiple choice reading comprehension tests. Factor analyses indicate that for both deaf and hearing children only one, general factor determines the reading comprehension item scores. For deaf children, factor analyses were only performed on the tests for Grades 2, 3 and 4. For Grades 2 and 4, the one-factor model for hearing children is also adequate to describe the reading comprehension performance of deaf children. No group factors were found, pointing to particular item characteristics that influence reading comprehension. Subsequent analyses of the role of different a priori item categories failed to show significant effects of such categories on deaf and hearing children's reading comprehension scores. Specific analyses for the effects of MOA, however, found that, for most grades, MOA correlates with the proportion of items that are answered correctly. Only at second grade level MOA did not significantly correlate with the item scores. This latter result is in line with the earlier finding (Chapter 3) that, at this level, reading materials predominantly contain word meanings that are acquired mainly through perception. For deaf children, high MOA values of the words in the test items are related to a lower proportion of correct answers at all grade levels, from third grade on. For hearing children, high MOA is only related to a lower proportion of correct answers at third and fourth grade level.

Based on the results of Chapters 2 to 5, a theory to explain the reading comprehension differences between deaf and hearing children was proposed in the discussion chapter. Although word identification is one of the two central skills required in reading comprehension, it cannot explain the differences between deaf and hearing children. Therefore, the proposed theory focuses on the mode of acquisition of word meanings, a specific aspect of the second central component in reading comprehension, knowledge of word meanings. This theory suggests that word meanings are acquired through more or less complex combinations of perceptual and linguistic steps. Children will first acquire word meanings that consist mainly of perceptual elements and as they grow older, they will learn word meanings that are more linguistic in nature. Differences in language input between deaf and hearing children make acquisition of word meanings different as well. Less language input for deaf children results in less linguistic units in the mental lexicon (in spoken language or sign language units), which hinders acquisition of word meanings with strong linguistic elements. Consequently, problems will arise when deaf children have to read texts that contain many words that are supposed to be learned linguistically. Since children need linguistic experience to enrich their word meanings and concepts, plentiful language experience is extremely important. It is important that all children receive a broad range of linguistic and non-linguistic information in both explicit and implicit learning situations. It is essential to supply as many words as possible to enable the child to learn concepts with strong linguistic meaning elements.

SAMENVATTING

In deze dissertatie is het begrijpend lezen onderzocht bij een groot deel van de dove schoolgaande kinderen in Nederland. Specifieke aandacht is gericht op de rol van twee factoren in het begrijpend leesproces: woordidentificatie en de wijze waarop woordbetekenissen verworven worden, in het vervolg ‘mode of acquisition’ (MOA) genoemd.

Hoofdstuk 2 laat zien dat de begrijpend leesscores van dove kinderen in Nederland schokkend laag zijn. Een grote groep van 7- tot 20-jarige dove leerlingen liet een gemiddelde score zien op het niveau van groep 3 van het basisonderwijs. De gemiddelde scores op woordidentificatie voor de dove kinderen van verschillende instructieleeftijden (aantal jaren formele instructie) verschillen echter nauwelijks van de scores van horende kinderen, wat aangeeft dat de lage scores op begrijpend lezen niet worden veroorzaakt door lage scores op woordidentificatie. Berekeningen lieten zelfs zien dat, wanneer de scores op woordidentificatie op leeftijdsniveau zouden zijn, de scores op begrijpend lezen nog steeds laag zouden zijn.

De tweede onderzochte factor in begrijpend lezen was mode of acquisition. Mode of acquisition verwijst naar de wijze waarop kinderen (of volwassenen) de betekenis van een woord verwerven. Kort gezegd kan de betekenis van een woord verworven worden via perceptie van de referenten van het woord, via linguïstische informatie of via een combinatie van beide. Hoofdstuk 3 laat zien dat MOA betrouwbaar gemeten kan worden via beoordelingen door volwassenen op een vijfpuntsschaal die van voornamelijk perceptueel (lage MOA) naar voornamelijk linguïstisch (hoge MOA) loopt. De op deze wijze vastgestelde MOA bleek zich te onderscheiden van de op vergelijkbare wijze gemeten woordkenmerken concreetheid en voorstelbaarheid.

De door volwassenen gegeven MOA-beoordelingen zijn vervolgens gebruikt om vast te stellen of teksten in de opeenvolgende groepen van de basisschool verschillen in de MOA van de gebruikte woorden. De resultaten lieten over de opeenvolgende groepen een geleidelijke toename zien van de gemiddelde MOA van woordbetekenissen in teksten. Daarnaast bevatten teksten in de lagere groepen een hoger percentage woordbetekenissen die beoordeeld worden als woorden die via perceptie verworven worden, terwijl teksten vanaf groep 6 een hoger percentage woordbetekenissen bevatten die beoordeeld worden als woorden die via linguïstische informatie geleerd worden. Deze laatste bevinding steunt de veronderstelling dat een deel van de problemen die dove kinderen hebben met het lezen van teksten uit hogere groepen veroorzaakt wordt door de MOA van de woordbetekenissen in die teksten.

Na te hebben vastgesteld dat MOA een valide construct is en dat woorden in leesteksten van de opeenvolgende groepen in het basisonderwijs verschillen in MOA, is de rol van MOA bij begrijpend lezen bestudeerd. Hoofdstuk 4 laat zien dat MOA niet alleen voor dove, maar ook voor horende kinderen een rol speelt bij zinsbegrip. In een 'self-paced reading' taak waren de leestijden voor beide groepen langer voor linguïstische woorden dan voor perceptuele woorden. Bovendien waren de scores op de begripsvragen lager voor zinnen die een linguïstisch doelwoord bevatten dan voor zinnen met een perceptueel doelwoord. In leestijd werd voor geen van beide woordtypen een verschil gevonden tussen de dove en horende kinderen, terwijl voor beide woordtypen de scores op de begripsvragen lager waren voor de dove dan voor de horende kinderen. Dit resultaat laat zien dat voor de dove kinderen het begrip van zowel perceptuele als linguïstische items moeilijk is. Verder namen de leestijden af met leeftijd (oudere kinderen lezen sneller dan jongere kinderen) voor de horende maar niet voor de dove kinderen. De scores op de begripsvragen namen voor beide groepen toe. Voor de horende kinderen nam daarnaast ook het verschil tussen de perceptuele en linguïstische conditie af met leeftijd, voor zowel leestijd als score. Dit was niet het geval voor de dove kinderen. Dit verschil wordt wellicht deels veroorzaakt door de aanwezigheid van een plafondeffect op de perceptuele items bij de horende kinderen.

In hoofdstuk 5 is de rol van MOA bij begrijpend lezen onderzocht door het te vergelijken met andere mogelijke factoren, zoals woordenschat, syntax en de vaardigheid om inferenties te maken. Met het resultaat dat MOA betrouwbaar gemeten kan worden en dat testitems voor de opeenvolgende groepen verschillen in de MOA van de gebruikte woorden, worden de bevindingen van hoofdstuk 3 bevestigd. Verder laat hoofdstuk 5 zien dat van de onderzochte factoren alleen MOA de scores op de meerkeuzetoetsen voor begrijpend lezen beïnvloedt. Factoranalyses laten zien dat voor zowel dove als horende kinderen slechts één algemene factor de itemscores op de toetsen voor begrijpend lezen bepaalt. Voor de dove kinderen zijn de factoranalyses alleen uitgevoerd voor de groepen 4, 5 en 6. Voor de groepen 4 en 6 is het één-factor model voor de horende kinderen ook geschikt om de begrijpend leesprestaties van de dove kinderen te beschrijven. Er zijn geen groepsfactoren gevonden, wat er op wijst dat specifieke itemkenmerken het begrijpend lezen beïnvloeden. Analyses naar de rol van verschillende a priori itemcategorieën lieten geen significante effecten van zulke categorieën zien voor de dove en horende kinderen. Specifieke analyses naar de effecten van MOA vonden echter voor de meeste groepen een correlatie tussen MOA en de proportie correct beantwoorde items. Alleen bij de toets voor groep 4 werd geen significante correlatie gevonden. Dit laatste resultaat komt overeen met de eerdere bevinding (hoofdstuk 3) dat de leesmaterialen op dit niveau voornamelijk woordbetekenissen bevatten die met name via perceptie geleerd worden. Voor de dove kinderen zijn hoge MOA-waarden van de woorden in de testitems gerelateerd aan een lagere proportie correct beantwoorde items voor alle groepen vanaf groep 5. Voor de horende kinderen is dit alleen het geval bij de toetsen voor groep 5 en 6.

In het discussiehoofdstuk wordt op basis van de resultaten van de hoofdstukken 2 tot en met 5 een theorie voorgesteld ter verklaring van de verschillen in begrijpend lezen tussen dove en horende kinderen. Hoewel woordidentificatie één van de centrale vaardigheden in begrijpend lezen is, kan het de verschillen tussen dove en horende kinderen niet verklaren. Daarom richt de voorgestelde theorie zich op de MOA van woordbetekenissen, een specifiek aspect van de tweede centrale vaardigheid in begrijpend lezen, kennis van woordbetekenissen. Deze theorie suggereert dat woordbetekenissen verworven worden door meer of mindere complexe combinaties van perceptuele en linguïstische stappen. Kinderen zullen eerst woordbetekenissen leren die voornamelijk uit perceptuele elementen bestaan. Naarmate ze ouder worden, zullen ze woordbetekenissen leren die meer linguïstisch van aard zijn. Verschillen in taalaanbod tussen dove en horende kinderen leiden tot verschillen in het verwerven van woordbetekenissen. Minder taalaanbod voor dove kinderen resulteert in een kleiner assortiment aan linguïstische elementen in het mentale lexicon (in gesproken taal of gebarentaal), wat de verwerving van woordbetekenissen met linguïstische elementen in de weg staat. Als gevolg daarvan zullen problemen ontstaan als dove kinderen teksten moeten lezen die veel woorden bevatten die linguïstisch geleerd moeten worden. Een uitgebreid taalaanbod is noodzakelijk, omdat kinderen linguïstische ervaring nodig hebben om hun woordbetekenissen en concepten te verrijken. Het is dan ook van belang dat alle kinderen een brede range aan linguïstische en non-linguïstische informatie ontvangen in impliciete en expliciete situaties. Daarbij is het essentieel zoveel mogelijk woorden aan te bieden om het kind in staat te stellen concepten met sterke linguïstische componenten te verwerven.

CURRICULUM VITAE

Loes Wauters is geboren op 2 september 1976 te Gent, België. Na het behalen van haar Gymnasium diploma op scholengemeenschap R.K. Jansenius te Hulst in 1994, startte ze haar studie aan de Katholieke Universiteit Nijmegen (KUN). Na het behalen van de propedeuse Pedagogiek vervolgde ze deze opleiding en begon daarnaast met de bovenbouwstudie Onderwijskunde. In 1999 rondde ze beide studies af met een gecombineerd scriptieonderzoek naar de rol van gebaren in woordherkenning bij dove kinderen op het Instituut voor Doven te St. Michielsgestel. Later ontving ze een ISED-artikelprijs voor een artikel over dit onderzoek (Pedagogische Studiën, 78(4), 2001).

In 1999 startte zij haar werkzaamheden bij de secties Orthopedagogiek: Leren & Ontwikkeling en Opvoedingsfilosofie aan de KUN. In 2003 ontving zij voor haar onderzoekswerkzaamheden het Frye-stipendium toegekend. Naast werkzaamheden aan haar proefschrift, heeft ze van 2000 tot 2003 werkzaamheden verricht als juniordocent.

Loes is nu verbonden aan de Radboud Universiteit Nijmegen (voorheen KUN) als postdoctoraal onderzoekster. Als postdoc zal ze zich de komende jaren bezig houden met de evaluatie van een project waarin dove en horende leerlingen op een reguliere basisschool onderwezen worden door twee leerkrachten, één uit het reguliere en één uit het dovenonderwijs.

Studies on Atypical Communication

Ludo Verhoeven & Hans van Balkom (Editors)

The aim of this series is to advance insight into the processes of communication withing and across children and adults with special needs, including persons with learning disabilities, cognitive, physical and sensory impairments, and persons from culturally and linguistically diverse backgrounds. It combines interest in sociolinguistic and psycholinguistic accounts of the acquisition and transmission of language and communication in these populations, and in educational solutions to help individuals overcome or reduce communication disabilities and to support their participation in society.

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