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Cued Speech and the Acquisition of Reading by Deaf Children[1]

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The reading impairment of the majority of prelingually, profoundly deaf subjects (Conrad, 1979) results mainly from a deficiency of their primary linguistic competence. It is widely recognized that orally educated deaf children attain only limited ability in the reception and production of both oral and written language (see Quigley and Paul, 1984 for a review). The lack of adequate communication between the child and his environment, especially in early childhood, is often identified as the main cause of this situation. A number of alternative communication methods have been proposed as potential solutions in order to reduce the language impairment of deaf children.

The aim of this paper is to explore the effects of one of these methods, Cued Speech, on reading acquisition. In the first part, we will argue that Cued Speech might help deaf children to develop their primary linguistic competence. In the second part, we will suggest that the early acquisition of a Cued Speech vocabulary might help deaf beginning readers to develop efficient procedures for reading in an alphabetic orthography.

Cued Speech and Linguistic Development

An obvious factor that intervenes in the linguistic development of orally-educated deaf children is the fact that lip reading, though playing an important role in the perception of spoken language (Dodd and Campbell, 1987), is not sufficiently informative to provide the deaf subjects with full access to phonological information. This limitation led researchers to imagine improved and unambiguous communication systems (see Fant 1972, for a presentation of some of them). The system devised by Cornett (1967) utilizes 12 manual cues in English, 13 in French. The combination of the information provided by the cues and that provided visually on the mouth area allows the identification of what is said. Phonemes that are not distinguishable on the mouth (such as /p/, /b/, and /m/) are accompanied by different manual cues, whereas a single cue may be used to accompany phonemes that are clearly discriminated on the mouth, like /t, m, f/. In French, eight cues are manual configurations which identify groups of consonants. The other five cues identifying groups of vowels, are locations of the hand near the face. The combination of a manual configuration and the simultaneous hand location transmits information about consonant-vowel clusters. The combination of this information and what is visible on the mouth permits identification of each individual consonant-vowel syllable. Consonant-vowel-consonant and consonant-consonant-vowel syllables require a separate cue for the additional consonant.

Theoretically, a message delivered by Cued Speech presents no more ambiguity for deaf children than does an oral message for hearing children. Two experimental studies (Nicholls & Ling, 1982; Périer, Charlier, Hage & Alegría 1985) have shown that deaf children extract more linguistic information when the speaker adds the cues to what is visible on the lips than when he does not.

Whether early exposure to Cued Speech allows deaf children to improve their primary linguistic competence is still a controversial question. From available data (Nash, 1973; Cornett, 1973), one may conclude that children who have been exposed to Cued Speech from before age one seem to acquire receptive vocabulary at the same rate as hearing children do. On the other hand, Nash (1973) observed that one child exposed to Cued Speech for two years developed little expressive skill in oral language, though his receptive language was essentially normal. Mohay (1983) reported that three children exposed for six months, nine months and 25 months, did not develop significant expressive skills in oral language. This disparity between receptive and expressive skills may be understood if one admits that "..Cued Speech will not of itself produce in a child the ability to make the sounds of speech. Parents or therapists must elicit sound productions in the hearing-impaired child if speech is to be the initial expressive mode" (Cornett, 1973, p.96).

In summary, the available data indicate that early exposure to Cued Speech favors the acquisition of a large receptive vocabulary. One might also expect that Cued Speech could help deaf children overcome their difficulties in acquiring a full and accurate phonological system (see Hudgins & Numbers, 1942; and Dodd, 1976), since it allows the receiver to perceive the existence of phonemes which are difficult to identify on the mouth only. Such problems in phoneme identification result for example, from the place of articulation, as in the cases of /k/ and /g/, or from the position

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in the speech stream (as when /s/ precedes another consonant). In addition, since it indicates in a distinct way several morphological markers (e.g. gender, number) which are difficult to distinguish on the lips, Cued Speech might enhance the acquisition of morphological knowledge--generally reported as being very limited in orally educated deaf children (Swisher, 1976). Finally, if adequate help were provided to elicit speech production, one might expect that the positive effects of exposure to Cued Speech on the receptive level might transfer to the oral expressive skills of deaf children.

Cued Speech and the Development of Reading

To discuss the possible influence of Cued Speech on the reading procedures of deaf children, we shall first summarize the role played by phonological codes in the reading of hearing subjects. Next, we shall show that the use of these phonological codes is limited in orally educated deaf subjects and that alternative codes cannot fill all the functions of phonological codes. Finally, we shall suggest that exposure to Cued Speech may favor the acquisition and use of phonological codes by deaf children.

The Role of Phonological Codes in Reading in Hearing Subjects

In hearing children, the development of oral language leads to the internalization of phonological representations, that is, mental representations of speech. These representations support the understanding and the production of speech, but they also play a role in thinking processes. We will focus here on their role in word identification, an activity which is generally considered as an important part of the reading process (Stanovich, 1982).

The phonological representations stored in the lexicon (sometimes called the *addressed phonology*) are used for short-term retention of words, regardless of whether the input items are spoken or written (Conrad, 1962; 1963; 1969). Indeed, these representations may be activated after the printed word has been recognized, because all the word's attributes (orthographic, semantic and phonological) are stored together in the lexicon. They could intervene in reading sentences, at least when the retention of the surface features of a text is required (Slowiaczek & Clifton, 1980). A reasonable assumption is that children would rely more on this phonological code during reading, because of the slowness of their word recognition processes (Baddeley, 1979).

These phonological representations may be segmented into sublexical units, the phonemes, corresponding approximately to the letters of the alphabet. This allows the hearing child to learn the grapho-phonological conversion rules. The application of the grapho-phonological conversion rules to a printed word results in assembling a phonological representation, which allows the reader to access the lexicon, just as it would be accessed from an auditory input. The importance of the intervention of the phonological (or indirect) access in written word recognition varies with reading ability. In skilled readers, printed words are often recognized by the orthographic (or direct) access, which consists in matching the stimulus with an orthographic representation already stored in the mental lexicon. The assembled phonology intervenes only in the recognition of low frequency words (Seidenberg, Waters, Barnes & Tanenhaus, 1984; Waters, Seidenberg & Bruck, 1984).

The role of phonological access is more important in beginning readers, who are able to recognize auditorially thousands of words and to understand their meaning, but lack a procedure to access the same information from print. Grapho-phonological conversion constitutes a generative procedure which allows them to become autonomous readers (Liberman, 1973, 1983). Indeed, hearing children who have mastered these conversions do not need any help to identify the meaning of regular words. Moreover, it has been argued that phonological access might help hearing children to build the orthographic access to the lexicon. For a child able to identify an unfamiliar word through phonological conversions, each new and successful encounter will act as a learning trial, and the child will become sufficiently familiar with the printed word to identify it visually (Jorm & Share, 1983). Another possible role is that the use of grapho-phonological conversions may facilitate the memorization of the orthographic representations (Ehri, 1980). That is, the hearing child has the potential to construct mental orthographic representations for speech units corresponding to those he knows by ear and will have only to check the correspondence between the predicted representation and the real one. He has only to retain the arbitrary orthographic characteristics for the words (Content, Marais, Alegría & Bertelsen, 1986).

These views are supported by different lines of research. First, numerous studies carried out on beginning readers show strong correlations between performance in speech segmentation tasks and reading tests. Furthermore, the hypothesis that speech segmentation abilities directly influence reading development is supported by several training studies (see Morais, Alegría & Content, 1987, for a review and discussion). A second line of evidence comes from comparisons of good and poor readers. Several studies have shown that poor readers, classified on the basis of reading comprehension tests, are less efficient than good readers in word recognition tasks. The difference observed between the two groups is larger for low frequency words and pseudo-words than for high frequency words, supporting the notion that the assembly process is one locus of difficulty in poor readers (Perfetti and Hogaboam, 1975; Hogaboam and Perfetti, 1978; Perfetti, Finger & Hogaboam, 1978; and Backman, Bruck, Herbert & Seidenberg, 1984).

The Use of Phonological, Sign and Orthographic Codes in Deaf Children's Reading

One might wonder whether this view of reading acquisition is appropriate or not for deaf children. Many educators consider that it might be more appropriate to encourage deaf children to use sign or orthographic coding strategies in reading, because of them phonological impairment. Against this view, we shall argue first that deaf subjects may use, and do use, phonological representations in reading, and that the extent to which they rely on phonological information is correlated with their reading ability. Secondly, we shall claim that other codes (sign or orthographic may fill *some but not all* of the functions filled by phonological codes in hearing subjects.

The use of phonological codes

Deaf children may use the information provided by lipreading, articulatory feedback, and residual hearing to develop mental representations of speech, based on auditory, articulatory, and labial cues. People experienced in fingerspelling may internalize dactylic representations (Morkovin, 1960). The lexical phonological (or dactylic) representations may play the same role in deaf subjects as the addressed phonology does in hearing subjects. Additionally, these representations may be segmented into sublexical units. As a result, they may allow deaf subjects to understand the regularities in the related phonological segments and sequences of letters and to develop a mechanism of phonological access to the lexicon. Note that this is probably easier to do with fingerspelling, in which each manual handshape represents a single letter of the printed word. Since these phonological (or dactylic) codes can fill the same functions in deaf subjects as they do in hearing subjects, a relationship between the use of phonological codes by deaf subjects and their reading achievement should be expected.

Empirically, it has been shown that speech and dactylic codes are used by some deaf individuals in tasks requiring short-term storage of written English materials (see Conrad, 1979, for a overview of the memory experiments). Subjects are presented with printed stimuli (e.g. words) and have to recall them in the same order in which they appeared. It is generally observed that the performance of hearing subjects is worse when the words rhyme than when they do not, indicating that the subjects translated the visual stimuli into a phonological code.

Conrad (1979) carried out a detailed investigation of the empirical relationship between the use of a speech code in short-term memory and other variables in an orally educated population of students (virtually all the deaf school leavers in Great Britain). By comparing the performance for a set of rhyming words to the performance for a set of visually similar words Conrad calculated an "internal speech ratio" (ISR) for individual subjects. He found that the proportion of subjects whose ISR was positive was smaller for deaf than for hearing subjects, and declined as hearing loss increased. In addition, the presence of internal speech was closely associated with the quality of vocal speech, since the proportion of subjects who use internal speech declined as speech intelligibility became worse.

Finally, there was a strong relationship between internal speech and reading level. Students with positive ISR had reading achievement scores from 1 ½to 2 ½ years ahead of those classified as not using internal speech. These results have been replicated by several investigators (Hanson, 1982: Lichtenstein, 1983a, 1983b; Hanson, Liberman & Shankweiler, 1984) who carried out experiments on native signers, with different measures of internal speech. Similarly, Locke and Locke (1971) presented subjects with lists of letters; and an analysis of confusion errors confirmed that some students relied upon dactylic coding.

It is worth wondering whether or not deaf readers are able to use, voluntarily or not, speech codes (addressed and assembled) in reading-related tasks, and whether the use of these codes is related to their reading ability. Among other data (Hanson, 1986; Hanson and Fowler, 1987), our own experimental work with the Stroop paradigm (Stroop, 1935) illustrates that internal speech may not be used in the same way, or to the same extent, by deaf subjects as it is by hearing persons. Subjects were presented with strings of letters of different colors. They were told to name the color of the strings and to ignore the letters. An interference effect is usually observed in that the color is harder to name when the letter sequence constitutes a color name presented in a incongruent color (e.g. RED printed in green ink) than when it constitutes a meaningless string (e.g. a sequence of consonants). This situation indicates that the word has been processed involuntarily. The interference observed is assumed to result mainly from the conflict between the phonological representation of the color name and the phonological representation of the word, which has been involuntarily activated. In several experiments, we showed that the interference was of the same magnitude in hearing and in deaf individuals considered as good articulators, while it was reduced in deaf subjects considered as poor articulators (Leybaert, Alegría & Fonck, 1983). However, sometimes even good articulators among deaf subjects behave differently from hearing subjects. For instance, in a task requiring subjects to detect a target letter in a text, silent letters are more frequently missed than pronounced letters by hearing subjects (Corcoran, 1966; 1967; Corcoran and Weening, 1968), suggesting that hearing subjects scan phonological representations of the words. In two experiments with profoundly, prelingually deaf children who had achieved good oral expressive skills (Locke, 1978; Leybaert, 1980), no difference was observed between detection of silent and pronounced letters, suggesting that deaf subjects carry out the task on a visual basis.

Some data indicate also that the use of an *assembled* phonological code is less extensive in deaf than in hearing subjects. This finding appears quite clearly in the following experiment, designed to examine whether deaf subjects involuntarily assemble a phonological code for pseudo-words. Using the Stroop paradigm already described, we compared the reaction time needed to identify the color of incongruent pseudo-homophones (like VAIRE and RAUZE, which are pronounced, in French, in the same way as the color names VERT (green) and ROSE (pink), to the time needed to identify the color of control stimuli (nonhomophonic pseudowords, like VOURE and RUIVE). The subject had to respond manually in one task and to name the color of the ink in the other. In the vocal task, the color was harder to name in the pseudo-homophones condition than in the control condition, for deaf as well as for hearing subjects. This indicates that the subjects of both groups have assembled automatically a phonological representation. In the manual task, hearing subjects also experienced more difficulty in responding to the pseudo-homophones than to the control stimuli, while the performance of the deaf subjects was virtually identical in the two conditions (Leybaert, 1987). Thus, while hearing subjects carried out the manual task on the basis of phonological representations, deaf subjects performed on the basis of orthographic representations.

There are also data indicating that although deaf subjects may segment dactylic representations (Hirsh-Pasek, 1987) and use the correspondences between the letters and the individual handshapes to help printed word identification (Ewoldt, 1981; Lichtenstein, 1983a, 1983b; Maxwell, 1984), they do not do this on all occasions in which it would be useful. Hirsh-Pasek (1987) found that deaf subjects identified more printed words when they were asked to fingerspell these words before giving their response than when they were not, suggesting that they did not spontaneously translate print into dactylic code.

If access to phonological information plays a positive role in the acquisition of literacy by deaf children, correlations between the use of phonological codes and measures of reading and spelling achievement should be expected. Working memory experiments have repeatedly provided such correlational data. Although this question has been little examined until now, in reading experiments conducted on deaf children, there is some evidence supporting this hypothesis. Hirsh-Pasek (1987) found that the reading ability of deaf subjects correlated significantly with their ability to segment fingerspelled handshapes, Another very indirect argument is that in all studies conducted on deaf readers who reach high reading levels, evidence for access to phonological information in reading and spelling has been found (Hanson, et al, 1983; Hanson, 1986; Hanson and Fowler, 1987). This fact is specially striking because these subjects were generally native users of ASL. Thus, phonological recoding is observed among deaf individuals who are good readers but whose primary linguistic development has not been in oral language. The next question, then, is whether deaf subjects' reading ability is correlated specifically or not with the use of phonological coding.

The use of sign and orthographic codes

Deaf children often have a certain amount of sign vocabulary before entering school, the magnitude of which varies, of course, with their propensity to use sign communication. Their lexicons contain sign representations to which orthographic representations are related when they learn to read. Consequently, an internal sign code could potentially play a similar role in deaf subjects as the addressed phonological code in hearing subjects. For deaf signers of American Sign Language (ASL), short-term retention of signs has been found to use a sign-based code (Bellugi, Klima & Siple, 1975; Frumkin and Anisfeld, 1977; Poizner, Bellugi & Tweney, 1981). Whether or not a sign code is internally generated in short-term retention of printed words is less clear (see Hanson, 1982; Lichtenstein, 1983a for negative evidence; and Shand, 1982, for positive evidence).

A sign code can also play a role in deaf subjects' reading similar to that of an addressed phonological code in hearing subjects. In an experiment by Treiman and Hirsh-Pasek (1983), subjects had to judge the grammaticality of printed sentences which, if recoded into sign, would contain many formationally similar signs. They found that, as a group, native signers made more errors on these formationally similar sentences than on control sentences, suggesting that the sentences were recoded into sign. It is interesting to note, however, that the best deaf readers did not show evidence of sign coding.

The fundamental point to be considered here is that sign languages differ from oral languages in the form of lexical structure. Sign structure is based on formational parameters (handshape, movement and place of articulation) which have no direct correspondence to English (or French) phonemes or graphemes. To make this more concrete, one can imagine the case of a deaf child who knows a particular sign and its meaning but who has never seen the corresponding word in print. When encountering this printed word for the first time, by himself he will not be able to access the knowledge he already has about this concept. In short, sign language does not allow deaf subjects to develop a procedure analogous to the phonological assembly in hearing children.

Since learning to read often means also learning a language for deaf children, these subjects might rely more than hearing people on orthographic representations of words. Orthographic code might play for deaf subjects a similar role to speech-based code in hearing subjects. A few experiments have provided evidence that, in short-term memory tasks in which most hearing subjects rely on a phonological code, some deaf subjects make use of an orthographic code (e.g. Conrad and Rush, 1965; Locke and Locke, 1971; Wallace and Corballis, 1973; Conrad, 1979; Lichtenstein, 1983a). It must be emphasized that the efficiency of a visual code may be strongly limited by the fact that written words often share many visual features (for a more detailed discussion of this point, see Conrad, 1979, pp. 170-171). If beginning deaf readers try to memorize orthographic representations of the printed words as if they were logograms (that is, without taking into account grapho-phonological regularities), they will encounter memory problems when the set of visually similar words becomes larger (Gough and Hillinger, 1980).

Linguistic coding in reading—conclusion

To summarize the discussion up to this point, deaf subjects seem to rely less than hearing ones on addressed phonology during reading; but this situation could perhaps be compensated for by the fact that they can use other codes (sign, orthographic) which may fill the same function. Deaf subjects also seem to rely less than hearing individuals on assembled phonology, but neither the sign code, nor the orthographic code, is able to substitute for phonological representations.

On the other hand, deaf children's reading ability is highly correlated with the use of phonological codes. It is likely that reading is facilitated, at some level, by the use of this kind of linguistic coding. Such coding is rather specifically phonological coding, since deaf children's reading ability correlates less or not at all with the use of sign code (Treiman and Hirsh-Pasek, 1983), or of an orthographic code (Lichtenstein, 1983b).

It would be interesting to know which variables contribute to the encouragement of deaf children to use phonological codes during reading. Among profoundly deaf subjects, the quality of the phonological representations might play a determinant role. Indeed, if the representations are difficult to distinguish from each other by the deaf subjects themselves, they are unsuitable to maintain information in memory. If the phonological representations bear little relationship to the true phonological structure of the words, deaf children would derive less advantage from the use of the phonological access. Another factor may be that the number of phonological representations that deaf children have internalized before entering school is sometimes very limited.

These considerations lead one to think that such communication systems as would improve the quality and quantity of phonological representations are likely to increase the use of phonological codes in reading by deaf children.

Cued Speech and the Use of Phonological Codes by Deaf Children

In the first part of this paper, we argued that early exposure to Cued Speech might allow the deaf child to develop a large receptive oral vocabulary, and thus to internalize lexical phonological representations, consisting of lip movements and manual configurations in addition to the cues provided by residual hearing and articulatory feedback. Theoretically, since in Cued Speech all that is said is represented visually, these representations are as accurate and distinguishable from each other as are the representations extracted from speech by hearing children.

Such Cued Speech representations might fill for deaf subjects all the functions of phonological codes in hearing subjects. On one hand, they might support an addressed phonological code that would maintain the information in memory. Since the use of this code would be favored by the fact that the child's lexicon contains many distinct Cued Speech representations, one may wonder whether deaf children would use this kind of code as frequently as hearing children use the phonologically addressed code.

On the other hand, the structure of Cued Speech representations is very similar to the structure of spoken words because it is constituted by a sequential production of syllables and/or phonemes. Cued Speech representations can be segmented at the syllabic level, and also at the phonemic level. Indeed, each of the two parameters (the manual configuration and its location) that characterize a manual cue corresponds, in combination with what is visible on the lips, to one precise phoneme. This might allow deaf children to establish a system of correspondences between the graphemes and the segmented Cued Speech representations of words. Such a system might fulfill for deaf children the same functions as the assembled phonological code for hearing children--that is, to decode unfamiliar print words into familiar Cued Speech representations which are part of their existing and well-established vocabulary, and to lessen the cognitive load represented by the memorization of orthographic representations.

Whether deaf children who have been exposed to Cued Speech do develop addressed and assembled phonological codes is an empirical question. We conducted several experiments on this topic (see Alegría & Leybaert, 1987 for a report of some of them). Some of the results suggest that deaf children do develop an assembled phonological code based on the correspondences between graphemic segments and their Cued Speech representations (Alegría, Lechat & Leybaert, 1988), while others do not permit us to find such evidence.

Whatever the definitive answer to this question, it will contribute to a better understanding of the questions raised by reading acquisition in deaf children. If we establish that deaf individuals do develop addressed and assembled Cued Speech codes, then we might expect them to acquire reading in a way more similar to hearing children. This situation might help to overcome the reading difficulties generally encountered by deaf subjects. On the other hand, if negative results are confirmed, at least two questions need to be answered: (1) Why do deaf children not make use of procedures which are available to them? and (2) What can educators do to favor the development of information-processing mechanisms based on Cued Speech vocabulary before teaching reading, and to convince deaf children (and their parents) more explicitly that Cued Speech may help them to identify unfamiliar printed words?

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