Structural vs. Semantic Coding in the Reading of Isolated Words by Deaf Children

Adele Cavedon, Cesare Cornoldi, and Rossana DeBeni
Institute of Psychology
University of Padova, Italy

It is well known that deaf children experience great problems in reading. The paper explores the deaf problems in reading isolated words with a continuous recognition task, including 20 "basic" words and four distractors selected for the basic words on the basis either of structural similarities (visual and phonetic) or semantic connection (a synonym or a strongly associated word). Deaf children, 11-15 years old, were compared with hearing children matched for grade (experiment one) and for age or school achievement (experiment two). Patterns of confusion, inferred by false positives, indicated that hearing children relied more on semantic properties of items and deaf children more on structural properties. This result contrasts with the idea that deaf reading difficulties are mainly related to an absence of structural processing of items and suggests that their main problem concerns a less deep coding of items during reading.

It is well known that deaf children experience great problems in reading. This deficit has been sometimes quantified for British and North-American children in terms of a reading ability development less than half that children with normal hearing (Conrad, 1977; Di Francesca, 1972, reported in Kyle, 1982). The reasons for this deficit have not been extensively studied, but the idea that it is connected to the specific acoustic-linguistic deficit of deaf people is largely accepted (Myklebust, 1964). In particular, the reading difficulties of deaf children should be connected to their lower linguistic competence and to the partial or total absence of phonological processing during reading. Phonological processes, which are often stressed as fundamental in reading, have been directly associated with the reading difficulties of the deaf (Conrad, 1972, 1979).

The present study explores the use of structural and semantic codes in deaf and hearing children. A continuous recognition task employed distractors similar to positive items, in different respects. Mark, Shankweiler, Liberman, and Fowler (1977) found that the false-positive errors for good readers in a word recognition test were considerably greater in number when the foils rhymed with the initial stimulus word than when they did not, but the rhyme/non-rhyme variable had little effect on error rates of poor readers. This result was interpreted as indicating that

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Cavedon's address: Institute of Psychology, University of Padova, Padova 35139, Italy.

good readers retain, although sometimes in an imperfect way, the phonetic information included in the words that they read, whereas poor readers tend to lose it. This result was confirmed by Byrne and Shea (1979) for poor readers and was extended by Frumkin and Anisfeld (1977) to deaf children. The study of the coding strategies of English speaking deaf children reading isolated words gives additional evidence to the acoustic and articulatory deficit hypothesis (Locke, 1978; Wallace & Corballis, 1973). Wallace and Corballis have observed that deaf children made extensive use of visual coding in the short-term processing of 4- and 5-letter sequences. A hearing group relied mainly on acoustic and articulatory coding.

As Quinn (1981:140) has observed, "several investigators have argued that the deaf child's reading difficulties may reflect his inability to access a verbal code, forcing him to rely on an inefficient visual code . . . . This hypothesis is far too simple, however, given the evidence that congenitally deaf readers may have knowledge of phonological rules . . . . While lipreading can provide only limited speech cues, given the visual similarity of different phonemes on the lips, this skill may serve as a major source of phonological information for the deaf child."

It is not completely clear how the deaf derive from lipreading either phonological or articulatory or speaking competence, but it is obvious that, by learning to speak, the deaf child acquires knowledge of the articulatory (more than of the phonetic) features of phonemes. Further, articulatory similarities between letters are somewhat comparable to phonetic similarities. It appears that deaf people can be influenced, in memory tasks, by "pronounceability" effects (see, e.g., Dodd & Hermelin, 1977). If deaf problems during reading are not related to a poor extraction of structural (mainly phonological and articulatory) features, they should related to a poorer coding at other levels, probably syntactic and semantic.

As Quinn has observed, lipreading (and oral methods which stress the relevance of lipreading) should affect the cognitive competence of deaf children. This idea, however, is not confirmed by experimental results obtained in the United States. Wallace and Corballis (1973) did not observe differences between orally and manually trained deaf children. Quinn herself (1981) did not observe any relationship between aspects of the deaf child's reading performance (in this case, regarding the sensitivity to orthographic regularities) and the type of communication method used in training. Nevertheless, it is possible that with Italian children who are for the most part trained with the oral method (in Italy there does not exist a real sign language), differences in coding processes during reading can be found. Italian oral methods attribute great importance to the observation of the external articulation of the mouth and to imitation. Further, in Italian there is a close correspondence between how a word is spelled and how it is pronounced. These two facts could imply that deaf children are affected by phonetic-articulatory similarities in the stimulus materials in a measure comparable or superior to that of the hearing children.

In the present experiments we wanted to evaluate the presence of structural, including articulatory-phonetic, processes (as opposed to semantic processes) on the basis of distractors either structurally or semantically similar to positive items, which were incorrectly recognized in a continuous recognition task by deaf and hearing children. We had two groups of "structural" distractors—i.e., of items similar to positive items with reference to their non-semantic, superficial features. One rhyming group of distractors was phonetically-articulatorily similar to positive items (sharing many letters and rhyming with them). A second group included visually similar distractors, which, by sharing many letters and the general form with the positive items, probably provoked a coding which was similar both from an articulatory and from a visual point of view. It must be remembered that Italian phonetic regularities make it difficult to find words which are written in a similar way (i.e., visually similar) but are pronounced in a different way (i.e., articulatorily dissimilar). These distractors differed from rhyming distractors principally in that they did not rhyme (as, for example, *gatto* (cat), *gesto* (gesture).

Since we intended to contrast the presence of a structural coding with a semantic coding, we introduced a corresponding number of categories of semantically similar distractors. In one category we included distractors which were synonyms of positive items; in the other category we included distractors which were strongly associated to positive items. If deaf children scarcely rely on structural properties of the items, they could be oriented towards a coding of their semantic properties. But if, when the deaf read, they also code phonetic, articulatory, and visual features of words, we expect that their structural errors will not be less than their semantic errors. Our expectation was that Italian orally-trained deaf children rely on structural features, but since their word processing is less efficient than in hearing children they are less able to rely also on semantic features of the items. Further, the two different semantic categories allowed us to evaluate the accuracy of the semantic coding on the basis of the measure of the possible difference between associated words and synonyms incorrectly recognized. In fact, the false recognition of a synonym indicates that the subject's memory has simply lost the structural properties of the item, whereas in the case of the recognised associated words, some semantic information was also lost.

Experiment 1 contrasts groups of hearing and deaf children, matching them for grade rather than for age. In fact, in the school for the deaf where the experiment was carried out, all subjects had repeated a year and so it was impossible to have a simple control group matched both for age and grade. In a preceding study it was observed that by matching the groups for grade it is possible to obtain a similar overall memory performance (Cornoldi & Sanavio, 1980).

Experiment 2 includes two groups of deaf children of different ages and introduces in the continuous recognition task a simple task requiring semantic processing.

EXPERIMENT ONE

Method

Stimulus materials. 120 items forming a single list were used; 20 of these were "basic"—the others were "distractors", i.e., words that might for various reasons be confused with a basic word. For each basic word five distractors were selected, each connected to the basic word in a different way: the repetition of the word, a word visually similar, a word visually and phonetically similar, a word strongly associated (like "mouse" for "cat"), a synonym. A word was considered visually and phonetically similar when it was of the same length and had at least the four last letters in common with the basic word (it was rhyming for hearing children) (as the Italian words *gatto* (cat) and *fatto* (fact). A word was considered visually similar to the basic word when it shared at least 60% of letters and satisfied one or more of the following conditions: sharing also at least the first or the last letter and/or a sequence of two internal letters (like the Italian words *gatto* and *gesto* (gesture). At the same time the word had to not satisfy the phonetic-articulatory criterion of rhyming, but it cannot be excluded that, having many similar letters, such words also had articulatory similarities. Similarly it cannot be excluded that phonetic distractors, having many similar letters, had visual similarities. The words were all highly frequent in the language but were also controlled with respect to the common knowledge of the vocabulary of 10 to 12-year-old deaf children (examples of the items are given in Table I.

Subjects. 17 deaf children with deficit due to factors acting before or during birth, with absence of any other handicap, and with a severe to profound hearing loss (a

Table I. Examples of Items Used in Experiments One and Two.

Basic Word	Phonetical	Visual	Semantic	Synonym
SEDIA (seat)	MEDIA (mean value)	SERVA (maid)	TAVOLO (table)	SEGGIOLA (chair)
DONO (present)	TONO (tone)	DOPO (after)	PREMIO (prize)	REGALO (gift)
GATTO (cat)	MATTO (had)	GESTO (gesture)	TOPO (mouse)	MICIO (tom-cat)
BALLO (dance)	GALLO (cock)	BAFFO (moustache)	MUSICA (music)	DANZA (hop)
VENTO (wind)	LENTO (slow)	VETRO (glass)	FREDDO (cold)	ARIA (air)

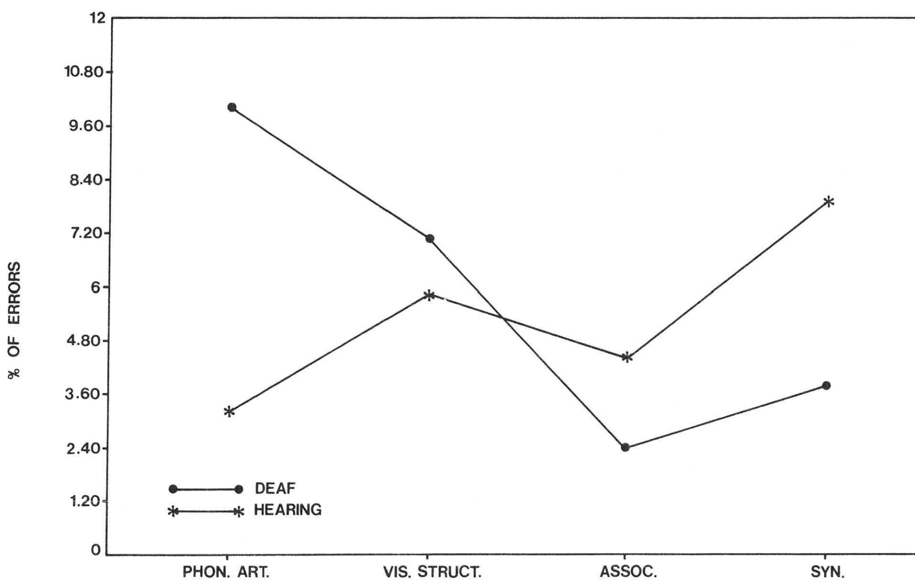
loss at the best ear superior to 70 db measured for the frequencies of 250, 500, 1000, 2000, and 4000 Hs.). The children, aged between 12 and 15, were all frequenting a special *prima media* (sixth grade) class for the deaf. The control group was formed by 17 children matched for sex, socio-economic status, and grade, and aged between 11 and 13.

Procedure. The continuous recognition task procedure which was used is characterized by the fact that presentation and test lists are mixed together. A single 120-item list including the 20 basic words, their repetitions, and the distractors was presented. Each word was printed on a separate card in italic characters. The 20 basic words appeared in the first 80 positions, whereas the corresponding repetitions and distractors were randomly dispersed after the appearance of the basic word. The mean distances between basic word and corresponding word were respectively 33.35, 32.9, 35.2, 32.75, and 31.85 words for repetitions, phonetic, visual, synonymic, and semantic association distractors. Words were individually presented at a 5 sec. rate and the subject had to indicate when a word had already appeared. Subjects were instructed to look only for exact repetitions of the words.

Results

Figure 1 shows the mean percentage of different errors for the two groups. A two-ways 2x6 ANOVA for mixed design (independent observations for the groups and

Figure 1. Mean percentage of distractors—similar to the positive items from a phonetic-articulatory, structural, associative, synonymic point of view—which were incorrectly recognized by a group of deaf children and by a control group of hearing children.



repeated observations for the kinds of errors) revealed a significant interaction groups x errors, $F(3,96)=6.6$, $p > .01$; and the difference between errors reached the .05 level of significance, $F(3,96)=2.70$. The Tukey a (Winer, 1962) procedure for a posteriori tests showed that, for the deaf group, the following differences between kinds of errors were significant: phonetic vs. semantic associations, phonetic vs. synonyms, visual vs. semantic associations and visual vs. synonyms.

Discussion

The interaction observed between groups and errors was clearly due to the fact that structural—and especially phonetic—similarities had a greater effect on the deaf children, while semantic similarities had a greater effect on the control group. The fact that the deaf also rely on a phonetic-articulatory code was confirmed by the observation that the deaf children tried often, during the task, to subvocally repeat the words. This result could also be due to the instructions given to the subjects which stressed the necessity of finding exact repetitions of items. Nevertheless, it must be observed that the deaf children—although presented a prevailing structural code—showed a good general memory performance. In fact, the mean numbers of the hits were 16.58 (82,9%) and 15.59 (77,9%) respectively for deaf and for control group, and the mean numbers of errors (false alarms) for the first presentations of the basic words were respectively .41 and .29. For controlling the role of instructions the following experiment modified the instructions introducing a very simple semantic requirement. Further, deaf subjects were differentiated for age (11-12 years vs. 13-14) with the purpose of seeing whether the phonological and articulatory awareness was more developed in older children.

EXPERIMENT TWO

Method

Stimulus materials. As in Experiment One.

Subjects. Subjects were chosen both from a school for the deaf in Padova and from normal schools where total integrations programs are carried out (such programs do not usually provide for repeating a year). Subjects were differentiated for age: 16 aged 11-12 (attending classes from the fourth to the sixth grade) and 16 aged 13-14 (attending classes from the sixth to the eighth grade). The subjects had auditory handicap comparable to those of Experiment One. All subjects had a mean hearing loss calculated at the best ear for the frequency of 250, 500, 1000, 2000, and 4000 Hz which was always superior to 75 db. For the control group we randomly selected 16 fifth-grade children. The control group was in this way matched for age with the younger deaf group, and for school achievement with the older group. Nevertheless, the deaf children revealed the usual reading comprehension deficit, obtaining at a reading test respectively the following mean scores: 4.3 for young integrated deaf, 6.44 for old integrated deaf, 2.63 for young non-integrated deaf, 2.38 for old non-integrated deaf (the score of hearing children was 7.94).

Procedure. Subjects were tested individually and at the appearance of each item had to make a particular sign when it was an animal (semantic task), and when they thought they had already read that item (memory task). To obtain both responses for the items the presentation rate was made free, but maintained overall times comparable to those of Experiment One. Subjects who were not able to carry out the semantic task were eliminated.

Results

The inclusion of the groups of deaf subjects attending different kinds of school was due both to the small groups of deaf subjects available and to the opportunity which in this way was offered to explore effects due to differences in instructional methods. Communities where seriously deaf children are integrated stress the relevance of promoting not only cognitive learning but also socialization with hearing, favouring in this way particular communication channels which the deaf can use with the hearing. Further, in these schools, failure at examinations is very infrequent. For analysing effects, due to the integration, a three-way 2x2x4 ANOVA concerning only deaf performance was carried where two variables (age, integration) concerned independent measures and the third (kind of error) concerned repeated measures, observing a significant effect due to the kind of errors, $F(3,84)=3.22$, $p > .05$, indicated about twice as many phonetic and visual errors as other kinds of errors. All the other F values were below 1. These results show that the performance observed in the deaf children in Experiment One was substantially repeated, independently from the fact that the instructions introduced a semantic requirement and independently from variables like age and the kind of school attended by the subject. For this last reason the integration variable was not considered further.

A second two-way, 3x4 ANOVA was carried out which included the control group and did not consider the integration variable, for mixed design (independent observations for the three groups, repeated observations for the kinds of errors). The only significant effect observed was the predicted effect, i.e., the interaction between groups and kinds of errors, $F(6,135)=5.7$, $p > .001$. Figure 2 shows that the effect was fundamentally due to the fact that hearing children make many synonymic errors, whereas deaf children reveal a reverse preference. Their structural errors are more frequent both with respect to semantic errors and with respect to the same categories of errors in the hearing subjects.

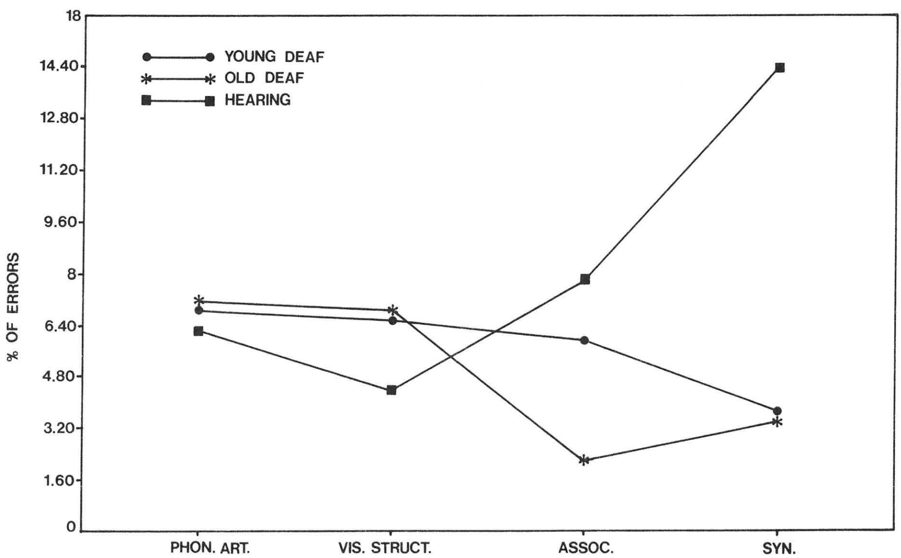
The mean numbers of hits (which were respectively 13.19 (66%) for young deaf children, 13.31 (67%) for old deaf children, 15.13 (76%) for hearing children), did not differ significantly, $F(2,45)=1.11$. Also, the mean number of false positives concerning the first presentation of basic words (which were very low in the groups, i.e., .125 (.6%) for young deaf children, .25 (2.3%) for old deaf children and .635 (3.2%) for hearing children) did not differ between groups.

Discussion

Before analysing in more detail the results obtained in these experiments, we want to discuss briefly a crucial point concerning the idea that we can deduce the prevailing code of a subject by the patterns of confusion by which he or she is especially affected. This idea occurs often in the literature (Byrne & Shea, 1979; Cermak & Butters, 1972; Frumkin & Anisfeld, 1977; etc.). Nevertheless, suppose that a subject relies only on a phonetic code but in a perfect way; he should not make phonetic errors. This is not the common case, since memory always loses some items of information, but in any event, we think that it is more prudent to interpret our results as indicating that deaf children, too, rely on structural (including phonetic-articulatory properties) of items rather than as indicating that they rely on them more than do hearing children.

Further, the clearly prevailing tendency of hearing children (with respect to deaf children) to rely on semantic properties of the items requires an explanation. Generally this difference in memory appears connected to the depth of the coding, in Craik and Lockhart's (1972) sense, and to memory performance, since memory performance is enhanced by a deeper coding (see, e.g., Jacoby & Craik, 1979). Nevertheless, in this case the groups did not differ significantly either in the number of hits or in the number of false positives, in both experiments. In other words the different processes activated by deaf and hearing children were equally functional for

Figure 2. Mean percentage of distractors—similar to the positive items from a phonetic-articulatory, structural, associative, synonymic point of view—which were incorrectly recognized by two groups of deaf children, respectively 11-12 and 13-14 years old, and by a control group of hearing children, in a continuous recognition task including a semantic requirement.



memory performance. This result could be due either to a very efficient structural code adopted by the deaf or to the fact that the deaf also have semantic processing but of a more nominalistic kind, as in the young hearing child who identifies a noun and its meaning (Piaget, 1945). It is, in fact, particularly surprising to observe the low number of synonyms incorrectly recognized by deaf children even in Experiment Two which was more semantically oriented.

These rather hypothetical considerations lead us to think that deaf reading difficulties not only cannot be attributed to an absence of phonetic-articulatory coding during reading, but also could be tentatively attributed to insufficient semantic processing of the items.

On the other hand, the presence of structural (including phonetic-articulatory processes) in 11 to 14-year-old children does not testify to their presence in 6 to 7-year-old children approaching the first phases of learning to read, in which the role of phonetic-articulatory competence can also be greater. In any event it was a little surprising not to find great differences between younger and older deaf children. Older children revealed only a slightly superior reading comprehension level and comparable error tendencies with a minor tendency to falsely recognize associated distractors.

Since we were forced to test almost all the deaf children at our disposal, there was not the possibility of a more accurate selection of subjects but—with respect to hearing deficits and other variables affecting school achievement—there were no evident differences between the two groups. Our results could indicate that differences in cognitive development and learning to read between 10-11 and 12-13 years are in deaf children very slight.

Hearing children made a larger number of errors with synonyms than with associations, but this trend—indicating accurate semantic coding—was not clearly present in deaf children. Rather, in the younger deaf group, an opposite trend appears which is not present in the older group. This is the only difference we observed in the two groups, but we cannot connect this difference to reading comprehension ability, which was extremely low in both groups.

The two different categories of structural distractors do not allow clear comparisons because of the difficulties of distinguishing between them in the Italian language. In any event we can observe a slightly greater tendency in deaf children, with respect to hearing groups, to rely on visual rather than phonetic properties. Nevertheless, this tendency does not deny the main result concerning the greater frequency of both kinds of structural errors in deaf subjects. It must also be observed that the visual errors, too, could be due either to phonetic or to articulatory confusion caused by the higher number of letters shared by basic and distractor words, the articulatory components having in this case probably a greater role than in phonetic, rhyming words. Further experimentation will try to distinguish between articulatory, phonetic, and visual errors, selecting words which are similar only either in the first group of letters or in the last group (and are rhyming) or share the general form and many non-consecutive letters.

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