Visual Perceptual Skills and Deafness: A Research Review

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Studies that have used visual perceptual tests to make inferences about the cognitive and language skills of hearing-impaired people are reviewed in this paper. The information they provide about those skills and about visual perceptual skills is critically examined. It is concluded that traditional hypotheses about perceptual functioning of hearing-impaired people cannot account for the pattern of differences between hearing-impaired and normal-hearing people indicated by this body of research as a whole.

This paper is a review of research that has used visual perceptual tests to make inferences about the cognitive and language skills of hearing-impaired people. Preparation of this review has been guided by two primary considerations. First, although many researchers have discussed the importance of studying visual perception in hearing-impaired people (Nickerson, 1978; O'Connor & Hermelin, 1978; Parasnis & Samar, 1982), there is no current comprehensive review of research on this topic. This information needs to be culled from the research on the cognitive and language skills of hearing-impaired people since, historically, visual perceptual performance was considered to be primarily a manifestation of these underlying skills, and was studied only in these contexts. Secondly, many of these studies have overinterpreted and overgeneralized from their data in drawing conclusions about the cognitive and language skills of hearing-impaired people. A critical review which summarizes the primary data and conclusions, therefore, is necessary to evaluate the accuracy and tenability of the information and conclusions from this research.

The task of providing a systematic and integrated overview of this literature is complicated by several factors. First, as pointed out by Hoemann (1978), in choosing hearing-impaired subjects, many studies have not controlled for differences in the amount of hearing loss, etiology of deafness, the time of onset of deafness, and the language(s) and/or mode(s) of communication used by their subjects. Each of these factors can have an important influence on the cognitive, and linguistic development of hearing-impaired

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people. Thus, the generalizability of the conclusions to hearing-impaired people is often questionable. Secondly, the diversity of topics investigated by these studies has led to a lack of common purposes and coherence of design across studies. Thus, the information gleaned from them about visual perceptual performance is fragmented. Thirdly, many studies have shown a lack of rigor in theorizing. The rationale for the studies and the implications of the findings are often not sufficiently articulated.

The organization of this review reflects the author's effort to accommodate the problems created by the diversity of topics, fragmented information and lack of a common theoretical framework. The review is divided into different sections according to the specific skills that these studies have investigated using visual perceptual tests. Within each section, each study's findings and conclusions are critically reviewed. The common conclusions that can be drawn about the visual perceptual performance of hearing-impaired people are discussed at the end of each section.

There are two long-standing and major hypotheses about the effect of deafness on the perceptual and cognitive functioning of hearing-impaired people which have been frequently invoked to explain patterns of visual perceptual performance. These hypotheses will be alluded to when discussing the studies that have referred to them, and therefore, a brief discussion of them follows.

Myklebust (1964) proposed that a deficit in one sensory system affects the development and organization of the other sensory systems, and, therefore, auditory impairment should lead to universally poorer visual perceptual performance. He also proposed that there might be specific perceptual deficits which reflect a deficit in general thought processes resulting specifically from language impairment in hearing-impaired people. Myklebust's propositions, commonly referred to as the *perceptual deficit hypothesis,* rest on assumptions that may not be correct. Although it is clear that sensory deprivation influences the functional and anatomical organization of the affected system (Hirsh & Leventhal, 1978), it has not been demonstrated that a deficit in one sensory system affects the normal development of the other sensory systems. Whether hearing-impaired people have a general "language impairment" is also questionable. Recent research has shown that American Sign Language (ASL), which is used by many hearing-impaired people in the United States, is a fully developed linguistic system (Siple, 1978). When ASL or manually coded English is acquired from early life by hearing-impaired people, it is quite possible that there is a normal development of language as a *general cognitive system.* Therefore, non-proficiency of the general deaf community in spoken language does not necessarily constitute a *language impairment* in this sense, and as such, may not be assumed to influence the normal development of thought processes.

Furth (1966, 1973) proposed that language impairment associated with auditory impairment limits hearing-impaired children's experiences with the world. This "experiential deficiency," it is proposed, leads to a lag in cognitive development which results in different performance patterns of hearing-impaired children compared to normal-hearing children in the same age group on perceptual and cognitive tasks. It is important to note that Furth assumes no fundamental differences in the developmental stages of hearing-impaired and normal-hearing people but considers the differences as arising from the differential *rate* with which hearing-impaired and normal-hearing children go through these stages. As discussed above, it is not certain whether auditory impairment is necessarily associated with a general "language impairment." Furthermore, Furth has not precisely defined the construct of experiential deficiency, nor has he established criteria to assess it. Thus, his *experiential deficiency hypothesis* has limited predictive power in determining performance on specific perceptual or cognitive tasks.

There is a third hypothesis, commonly called the *perceptual compensation hypothesis,* which postulates that a deficit in one system may cause a compensatory proficiency in the other sensory systems. No further elaboration of this hypothesis can be found in the literature and no major proponent is associated with it, although occasionally, it is referred to in discussing the perceptual deficit hypothesis, or in explaining superior performance of hearing-impaired subjects on any perceptual or cognitive task compared to normal-hearing subjects (Hoemann, 1978; Olson, 1967; Siple, Hatfield, & Caccamise, 1978).

There has not been a systematic theoretical or empirical effort to adequately elaborate these hypotheses to the point where they are conceptually well formed, properly defined operationally, and explicitly distinguishable from each other. There are, therefore, limitations in evaluating the relative adequacy of these hypotheses in explaining a given set of data. Furthermore, these hypotheses ignore the possibility that deafness specific alterations in information processing performance may result from the ecologically useful adoption of different general information processing strategies which may have been overgeneralized by subjects to testing situations (Parasnis & Samar, 1982; Siple, Hatfield, & Caccamise, 1978). Thus, studies which simply test the performance of hearing-impaired subjects relative to normal-hearing subjects, but do not challenge subjects to use what may be non-preferred processing strategies, produce results which fail to distinguish between "deficit," "superior ability," and the general efficiency of preferred strategies. Similar arguments have been made in the context of memory research on hearing-impaired people by O'Connor and Hermelin (1978). Their memory research is not reviewed in this paper since the primary focus of this review is on visual perceptual processes and not on memory processes. However, it is important to note that their research has shown that differences in performance on memory tasks can be explained due to differences in memory coding strategies used by sensory handicapped and normal people. Furthermore, these differences disappear when subjects are told to use a particular strategy. (See O'Connor and Hermelin, 1978, for detailed description and discussion of this research.) These results suggest that performance differences between hearing-impaired and hearing people can be task specific and do not reflect a generalized "deficit" or "superiority" of the cognitive functioning of hearing-impaired people. Thus, they support the notion of general information processing strategy differences between hearing-impaired and normal-hearing people. In reviewing the studies, the possibility of perceptual processing strategy difference will be discussed in more detail.

VISUAL PERCEPTUAL TESTS USED TO STUDY COGNITIVE SKILLS

Historically, non-verbal tests, including visual perceptual tests, were used to determine the intellectual skills of hearing-impaired people. The earliest work in this field is by Pintner, who designed and administered the first battery of non-verbal tests of intelligence for hearing-impaired people in the United States (Pintner & Paterson, 1919, 1923; Pintner & Reamer, 1916). Although Pintner (1931) found poorer performance of hearing-impaired children compared to normal-hearing children on this battery, the later research using different test batteries to measure intelligence showed that hearing-impaired children's average IQ falls within the normal range. For example, hearing-impaired children scored within the normal range on the Grace Arthur Point Scale of Intelligence, the Wechsler Intelligence Scale for Children (WISC), and the Nebraska Test of Learning Aptitude in several studies (Graham & Shapiro, 1953; MacPherson & Lane, 1948; Myklebust & Burchard, 1945; Shirley & Goodenough, 1932; Streng & Kirk, 1938). It is now commonly accepted by researchers and educators that hearing-impaired children do not differ from normal-hearing children when a quantitative measurement of non-verbal IQ is employed. (For a review of the IQ testing conducted on hearing-impaired children, see Vernon, 1968).

The above research was important in quelling doubts about the educability of hearing-impaired children. Also, this work inspired several researchers to study specific perceptual/cognitive skills in hearing-impaired people. These researchers suggested that even though the total IQ scores of hearing-impaired people may not differ from normal-hearing people, there may be significant differences on specific tests of perceptual/cognitive skills which require abstract thought (Larr, 1956; Myklebust, 1964; Oléron, 1950; Rosenstein, 1961). In general, their studies tested the hypothesis that language deficiency of hearing-impaired people would lead to deficiencies in perceptual and/or abstract thinking processes. The reader should bear in mind that the concept of abstract versus concrete thought has never been invested with adequate conceptual or operational definitions. Further, the link between deafness and "language" deficiency has not been adequately defined.

Templin (1950) found that hearing-impaired children performed poorer than normal-hearing children (10 to 20 years of age) on a non-verbal analogy task and concluded that hearing-impaired children were inferior to the normal-hearing children in abstract reasoning. Hiskey (1956), using the Nebraska Test of Learning Aptitude, found that hearing-impaired children were inferior to normal-hearing children (4 to 10 years of age) on the subtests which involved analogy and memory. He considered the hearing-impaired children's results to be due to limitations in symbolic thinking. Oléron (1950) found that hearing-impaired children (9 to 21 years of age) performed poorer than normal-hearing children on the Raven's Progressive Matrices Test which requires picking the correct form to complete a sequence. He concluded that hearing-impaired children's inferior performance on the Raven's indicated an underlying deficiency in performing abstract reasoning which requires deductive thinking. Although an early study by Ewing and Stanton (1943) supported Oléron's findings it should be noted that Smith (1952) and Farrant (1964) did not find inferior performance on the Raven's in their samples of hearing-impaired children (4 to 10, and 8 to 12 years of age) compared to normal-hearing children. Thus the reliability and generalizability of Oléron's findings is questionable.

The first extensive study of the visual perceptual performance of hearing-impaired children was conducted by Myklebust and Brutten (1953). To determine whether there were specific perceptual deficits in hearing-impaired children, they administered several perceptual tests to hearing-impaired and normal-hearing children (mean age 9.5 years) matched for their age and non-verbal IQ. The tests included the Marble Board Test in which a child has to create on her/his marble board a pattern identical to that created by the experimenter on another board, the Figure-Ground Test, the Perseveration Test, and the Pattern Reproduction Test which involved dot as well as line patterns. Myklebust and Brutten found that the hearing-impaired children performed significantly poorer than the normal-hearing children on the Marble Board Test, the Figure-Ground Test and on the Pattern Reproduction Test when it involved dot patterns. They suggested that these perceptual tests involved a general abstract thinking process and considered hearing-impaired children's poor performance the result of deficiency in abstract thinking process resulting from deafness as suggested by Myklebust's perceptual deficit hypothesis.

Myklebust and Brutten's conclusions have been criticized by Rosenstein (1961), who noted that it has not been demonstrated that these tests validly measure abstract thinking. Furthermore, he noted that the concepts of concrete and abstract thinking have not been adequately defined. Rosenstein questioned the appropriateness of inference about the higher order thought processes from perceptual performance and suggested that the differences between hearing-impaired and normal-hearing children may have been due to their difference on the perceptual style of field independence

dependence which refers to the ability to differentiate a figure from its embedding context and which is related to individual differences in psycho-social experiences (Witkin, 1959). Witkin's data, he noted, indicated that there is a developmental trend towards greater field independence and that there are individual differences in the amount of field independence developed at any given stage. Rosenstein suggested that the lower performance of hearing-impaired children on the Figure-Ground Test can be explained as the result of their being more field dependent (i.e., less able to differentiate figure from its embedding context) given their developmental experience.

Although Rosenstein did not discuss the results of the other two tests — the Marble Board Test and the Pattern Reproduction Test with dot patterns — the same construct can be applied to explain those results. Myklebust and Brutten considered these two tests as tapping the ability to perceive the whole pattern. Such ability, they considered, reflected abstract thinking processes. However, this ability to see the whole pattern is considered by Witkin (Witkin, Dyk, Faterson, Goodenough, & Karp, 1962) as another way of describing the perceptual style of field independence dependence. Relatively field independent people are those who tend to use an "analytical" perceptual strategy such that they can readily isolate a figure from its embedding context, while relatively field dependent people are those who tend to use a "global" perceptual strategy such that they are influenced by the whole structure and have difficulty in isolating a figure embedded in context. Witkin and his colleagues' research (Witkin et al., 1962) has shown that individual differences on this dimension reflect processing *strategy* differences and are not related to cognitive *capacity* differences. Thus, the hearing-impaired children's poor performance on the Marble Board Test and the Pattern Reproduction Test with dot patterns can be considered as reflecting their field dependent perceptual style and not their deficit in abstract thinking process.

Recently, Parasnis and Long (1979) tested 144 severely hearing-impaired college students (mean age 21 years) on the Group Embedded Figures Test (GEFT), which is a test of field independence, and found that hearing-impaired male and female students were more field dependent when compared to the normal-hearing norms (Witkin, Oltman, Raskin, & Karp, 1971). These students, however, did not differ in their performance on the Spatial Relations Test when compared to the normal-hearing norms (Bennett, Seashore, & Wesman, 1966). Similar results were found in another study by Parasnis (in press) which showed that although congenitally profoundly hearing-impaired college students did not differ from normal-hearing college students in performance on the Spatial Relations Test and the Abstract Reasoning Test, hearing-impaired female students were more field dependent than normal-hearing male and female students as measured by their GEFT scores (This study is discussed in another context later.) These results are consistent with Rosenstein's suggestion that hearing-impaired and normal-hearing people may differ in the development of field independence, and they support the notion that there may exist perceptual strategy differences between hearing-impaired and normal-hearing people.

Two studies, discussed below, were undertaken to test Myklebust and Brutten's (1953) conclusions. Neither of these studies supported the general perceptual deficit hypothesis.

Larr (1956) compared hearing-impaired children with normal and mentally retarded normal-hearing children on several perceptual and conceptual tasks. The non-verbal IQ of the hearing-impaired children and the normal-hearing children were matched. The age of these children is not reported. The perceptual tests were the Marble Board Tests, the Picture Test measuring figure-ground segregation and the Tactual-Motor Tests measuring the ability to draw figures perceived tactually. The Color Form Sorting Test, the Object Sorting Test and the Picture Object Test were used as conceptual tests. Larr found that hearing-impaired children performed poorer than normal-hearing children on the Picture Test, and on two conceptual tests, namely the Object Sorting Test, and the Picture Object Test. On the remaining tests, i.e., the Marble Board Tests, the Tactual-Motor Tests and the Color Form Sorting Test, the hearing-impaired and normal-hearing children performed equally well. These results do not support Myklebust's hypothesis about a generally lowered perceptual performance in hearing-impaired children. They also do not support Myklebust and Brutten's findings that hearing-impaired children perform worse than normal-hearing children on the Marble Board Test.

Rosenstein (1960) studied prelingually hearing-impaired children (8 and 12 years of age) and 60 normal-hearing students matched for age and non-verbal IQ. He administered a perceptual discrimination task, a multiple classification task and a concept attainment and usage task. He did not find any significant differences between groups on performing these tasks. Thus, the perceptual deficit hypothesis, which postulates abstract thinking deficit, is not supported by his data. Rosenstein considered the results consistent with his hypothesis that no differences between hearing-impaired and normal-hearing children will be observed when the conceptual tasks are within the linguistic capacity of hearing-impaired children. He further suggested that "in those previous findings where conceptual deficit has been reported, it seems likely that the tests have involved linguistic abilities beyond those of the children tested" (p. 119). The conceptual tests used by Rosenstein were different from those used by Myklebust and Brutten (1953) and Oléron (1950). Since Rosenstein has not offered any systematic comparison of the tasks, it is not clear why he considers it likely that the other tests involved greater language skills than those required by his tests.

Furth and Mendez (1963) studied the influence of language and age on performance on perceptual tasks that utilized the Gestalt principles of perceptual organization, namely, proximity, closure, good form, and similarity. Hearing-impaired and normal-hearing children tested were matched for age and non-verbal IQ. The subjects were divided into two groups whose mean ages were 9 and 16 years, and the hearing-impaired subjects were divided further into poor and good readers. The results showed no difference in performance between good and poor hearing-impaired readers. Furth and Mendez found that younger hearing-impaired children were different from hearing children on three out of the seven perceptual tasks. On the test of closure, the younger hearing-impaired children drew a geometric figure faster than the hearing controls. Similarly, on the test of good form, they persisted in recognizing a letter even though more and more distortions were added to it. The third difference was on the test of similarity which involved figure-ground separation, on which the younger hearing-impaired children performed worse than the controls. The older hearing-impaired children were different from their normal-hearing controls only on the test of closure. They were faster in recognizing an incomplete letter than the normal-hearing children. The results on the test of closure found for the young and old hearing-impaired children are consistent with the results of Siple, Hatfield, and Caccamise (1978) who found that closure speed is greater in hearing-impaired compared to normally-hearing adults. The results on the test of similarity found for the young hearing-impaired children are consistent with the earlier findings that hearing-impaired children perform poorer than normal-hearing children on the tests of figure-ground segragation.

Furth and Mendez (1963) considered these results as supporting Furth's experiential deficiency hypothesis which postulates developmental lag in hearing-impaired children, since, on two out of the three tasks on which the difference was found in the younger hearing-impaired and normal-hearing children, the difference disappeared in the older children. Perhaps an alternative explanation may be that these results reflect the perceptual strategy differences among hearing-impaired and normal-hearing children. The test of closure and the test of good form can be considered as tests that involve perception of the whole structure, while the test of similarity can be considered as involving perception of a part embedded in the whole structure. If the younger hearing-impaired children compared to the younger normal-hearing children were more field dependent, one can expect that they would perform better on the tasks that involved a global perceptual strategy and worse on the task that required an analytical perceptual strategy. Such a hypothesis can also explain the better performance of the older hearing-impaired children on the test of closure as caused by their use of a more global perceptual strategy compared to the older normal-hearing children. However, it should be noted that this explanation is not complete since the older children did not differ on the other two tests in which the same strategy was presumably employed.

In summary, the results of these studies do not universally support the perceptual deficit, the perceptual compensation, or the experiential deficiency hypothesis. It was suggested that hearing-impaired people may differ from normal-hearing people in development of perceptual processing strategies such that they utilize a global rather than an analytical perceptual strategy. Such explanation can account for much of the difference found on the perceptual test performance of hearing-impaired and normal-hearing people.

VISUAL PERCEPTUAL TESTS USED TO STUDY COLOR AND FORM SORTING

All of the studies on this topic examined whether hearing-impaired children perceive specific stimulus dimensions of color and form in a similar way to normal-hearing children. The results of these studies consistently show that hearing-impaired children notice the dimension of color over form in sorting stimuli.

Heider and Heider (1940) conducted some of the earliest experiments on the color sorting behavior of hearing-impaired children. In a series of studies, they compared the behavior of prelingually hearing-impaired and normal-hearing children ranging in age from 5 to 19 years in selecting a series of related hues which match the standard to investigate whether hearing-impaired children can use a general category concept in color sorting. They based their experiment on the findings of Gelb and Goldstein (1925) which showed that aphasics tend to select an exact match when asked to select a *series* of related hues which would match the standard. Since the hearing-impaired child shares the superficial similarity of severe spoken language restriction with the aphasic, Heider and Heider investigated whether hearing-impaired children would be similar to aphasics in color sorting behavior. The results showed that hearing-impaired children were comparable to normal-hearing children and not to aphasics. In fact, hearing-impaired children consistently selected a wider range of hues than normal-hearing children. Since young children tend to select a wider range compared to older children, Heider and Heider interpreted this difference to be indicative of a developmental lag.

Doehring (1960) constructed and administered a test of "color-form attitudes" in which two dimensional stimuli could be sorted either on the basis of color or form. He tested hearing-impaired and normal-hearing children ranging from 8 to 12 years of age and found that the hearing-impaired children chose to differentiate on the basis of color. He tested young normal-hearing children (4 to 5 years) and adult normal-hearing people to see if there was a developmental difference in choosing on the basis of color and did not find any differences. He concluded that the hearing-impaired children's preference for color was not due to a developmental lag.

Gaines (1964) matched prelingually, severely hearing-impaired and normal-hearing children (8 to 11 years of age) on age, sex, socioeconomic status and race. The children had normal non-verbal IQ, and normal color vision.

Gaines tested the children on color preference and on color and form discrimination ability by giving them a series of figures varying in hue saturation and varying in degrees of internal angles. She found that hearing-impaired children preferred color more than normal-hearing children and discriminated color more accurately than normal-hearing children.

Wiig and Neurman (1972) studied selection preference for the dimension of color, form, orientation, and size of visual stimuli in prelingually and severely hearing-impaired and normal-hearing children (6 to 10 years of age) who were matched for age, sex, and IQ, and had no known visual problems. The subjects' task was to match a sample stimulus with one of the four comparison stimuli, each of which differed on one dimension from the sample stimulus. Wiig and Neurman found that, except for the size dimension, the dimension selection of the two groups was not different. Size was chosen much less frequently by the hearing-impaired group than the normal-hearing group. If the sample stimulus was, for example, a red large triangle oriented to the right, a hearing-impaired child was more likely to pick a red small triangle oriented to the right, while a normal-hearing child was more likely to pick a green large triangle oriented to the right. Since an identical match with the sample was not included in the comparison stimuli, the children had to decide which dimension could be ignored in picking an approximate match. Wiig and Neurman considered size to be a "concrete" dimension and interpreted the hearing-impaired children's less frequent use of it, compared to the normal-hearing children, as indicative of a relatively greater degree of abstract behavior. Thus, they considered their results as contrary to the perceptual deficit hypothesis. Also, they suggested that the hearing-impaired children's less frequent use of the size dimension may be because size has lost its salience for them since it is not a useful dimension in developing speechreading skills. This study certainly points to a difference in relevance of the size dimension for hearing-impaired and normal-hearing children in attending to multi-dimensional stimuli, but the assumptions about the "concreteness" of the size dimension or the role it plays in learning to speechread need to be tested before accepting the authors' interpretations.

Furth (1961) gave a non-verbal paired associate task to prelingually, moderately hearing-impaired and normal-hearing children (7 to 12 years of age). The subjects' task was to associate four colors with two toys (two colors for each toy) and a successful performance was defined as correct association for 10 trials in succession. The results showed that the hearing-impaired and hearing children did not differ in their performance from the ages of 7 to 10 years but at the ages of 11 and 12 years, the normal-hearing group performed significantly better than the hearing-impaired group. Furth interpreted these findings as supporting the experiential deficiency hypothesis since only the older children differed on the task. He suggested that deficiency in experience and training may have affected the cognitive and motivational learning attitudes of the older hearing-impaired children which resulted in their inferior performance on the task.

Furth and Youniss (1964) compared hearing-impaired students (10 to 11 years and 6 to 7 years of age) and normal-hearing children of the same ages on tasks which required a paired associate learning of color and object. In one task, colors associated with toys were neutral while in the other, they presumably created interference. The four toys used in the experiment were conventionally colored (e.g., black locomotive, green tree) and the interference was created by asking the child to associate a different color to the toy (e.g., green with black locomotive). The response measure was the number of trials to the criterion of correct association. The results of an analysis of variance of the data showed that younger children required more learning trials than the older ones, and both groups required more trials to learn the interference than the neutral task. The interaction between tasks and normal hearing status was not significant. Furth and Youniss also carried out t-tests which revealed that the interference task was more difficult than the neutral task for the normal-hearing children at both ages, while there was no difference in task difficulty for hearing-impaired groups at both ages. These t-tests, it should be noted, are inappropriate since the interaction between task and normal-hearing status was not significant and as such, little credence can be placed on either the results or their interpretation.

Furth and Youniss suggested two possible interpretations of their t-test results. One was that verbal mediation in normal-hearing children may have created more interference in associating unconventional colors with toys. The second was that hearing-impaired people, being experientially deficit, did not have strong associations between conventional color names and the objects the toys represented and hence, there was no difference in their performance on the two tasks. Both of these interpretations are so general and ad hoc in nature that they can be applied to opposite outcomes with equal facility. Let us assume that the hearing-impaired subjects were the ones who found the interference task more difficult than the neutral task. Then the two interpretations can be given as follows: a) there was no difference in performance on the two tasks for normal-hearing people since their verbal superiority allowed them to learn to associate unconventional color names as easily as the conventional color names with toys, and b) the experiential deficiency of hearing-impaired people led to a relatively rigid tendency to stick to the learned associations between conventional color names and the objects toys represented, and thus, the interference task was more difficult for them than the neutral task. This interpretive exercise illustrates the fallibility of the authors' ad hoc arguments.

In general, the studies on color-form sorting have shown that hearing-impaired children notice color over form. The data available do not allow definite conclusions concerning the nature of this perceptual performance. It is as viable to suggest that these results indicate a developmental lag (as suggested by some of these studies) as it is to suggest that these results reflect a perceptual processing strategy difference such that hearing-impaired children are attentionally more attuned to color dimension than normal-hearing children.

VISUAL PERCEPTUAL TESTS USED TO STUDY LANGUAGE SKILLS

The general motivation for these studies seems to be to identify those perceptual skills which are related to development of language skills by hearing-impaired people. In general, language in these studies has been operationally defined as reading or speechreading skill.

A study which is often quoted in the literature as showing a relationship between visual closure and speechreading skills was conducted by Sharp (1972). She investigated the relationship between visual closure and speechreading skills in prelingually, severely hearing-impaired children with no known visual defects. She tested good and poor speechreaders selected on the basis of their scores on a speechreading test developed by the author. The visual closure tests used included the Visual Closure Subtest of the Illinois Test of Psycholinguistic Abilities; the Porteus Maze Test; the Picture Completion Subtest of the Nebraska Test of Learning Aptitude; a Hidden Object test; a Hidden Figure test; and two tests of Movement Closure. The last four tests were developed by the author and no information about their reliability or validity is given. The Visual Sequential Memory Subtest of the Illinois Test of Psycholinguistic Abilities was used to measure visual memory. Results of this study showed that good speechreaders scored significantly higher than the poor speechreaders on five out of the eight tests. Sharp considered these results as supporting her hypothesis that positive relationship would exist between closure skill and speechreading skill. It should be noted here that Sharp is referring to Type III visual closure described by Thurstone (1940) which refers to the selection of a figure embedded in a total configuration. Thus, the Type III visual closure definition is quite similar to the construct of field independence discussed earlier. Sharp's results, thus, seem to suggest that speechreading skill is positively related to an analytical perceptual strategy in prelingually hearing-impaired children.

Sharp's experimental design can be criticized on a number of methodological grounds. Since the reliability and validity data for four tests that she constructed are not given, it cannot be determined if the tests adequately measured visual closure. Since Sharp did not control the IQs of the good and poor speechreaders, it is possible that the good speechreaders were, in general, more intelligent than the poor speechreaders and hence, performed better on these tests. Furthermore, in order to show that a *specific* perceptual skill like closure skill was related to speechreading skill, tests which measure several different types of perceptual skills need to be included in the study. Otherwise, the relationship between a perceptual skill and speechreading skill can be considered as reflecting a general non-specific relationship between perceptual skills and speechreading. These problems limit the reliability of Sharp's conclusions.

Parasnis (in press) tested the relationship between the Group Embedded Figures Test which measures field independence or the use of analytical perceptual strategy, and several cognitive and communication tests in 38 congenitally and profoundly hearing-impaired and 29 normal-hearing college students (mean age 19.5 years). It was found that the congenitally and profoundly hearing-impaired students who learned ASL from birth showed a significant negative correlation (-.74) between field independence and speechreading skill; i.e., the more they used a global perceptual strategy, the better they were in speechreading. This relationship was not present for the congenitally and profoundly hearing-impaired students who learned sign language later in life (between 6 to 12 years of age). No significant relationships were found for either hearing impaired group between speechreading and other tests of cognitive skills such as the Spatial Relations Test and the Abstract Reasoning Test.

The results of these two studies suggest that there might exist a complex relationship between an analytical/global perceptual strategy and speechreading, the exact nature of which needs to be investigated further. As many researchers have noted (Farwell, 1976; Jeffers & Barley, 1971; Risberg & Agelfors, 1978), little is known about the specific factors that contribute to and/or predict speechreading skill.

Olson (1967) administered five "visual perceptual speed" tests and three English language tests to prelingually hearing-impaired children with average hearing loss of 85 dB (12 to 16 years of age). One perceptual speed test measured the speed of recognition of fingerspelled consonants. In that test the subject's task was to write down the four consonants that were shown on a speeded up film at 24, 20, 16 and 12 frames per second. (Originally the fingerspelling was photographed at 8 frames per second.) Olson's other four perceptual speed tests required identification of letter sequences, familiar words, pseudosymbolic forms, and geometric figures. The stimuli in each of these tests were tachistoscopically presented for 15, 55, 90 and 130 milliseconds. Upon factor analysis, Olson found that the test which measured the speed of recognition of fingerspelled consonants loaded highly on one factor along with English language tests. Olson concluded from his results that there is a positive relationship between "speed of visual perception" and language acquisition such that those who were quick in perceiving visual information were more likely to develop language at a faster rate.

In his paper, Olson has not given the correlational matrix, or the factor analysis data, or the complete list of factors that he identified, and thus, it is not possible to evaluate his results. The tests of perceptual speed have no reliability or validity data on them and seem to be confounded with language. Furthermore, there is no measure in the study to test the "rate" of language acquisition. It seems more reasonable to conclude from the data that the better the English language and fingerspelling skills, the better is the performance on recognizing fingerspelling than to conclude that the "speed of perception" increased the "rate of language acquisition."

Doehring and Rosenstein (1969) administered a test of "visual perceptual speed" to two groups of hearing-impaired (10 and 15 years of age) and normal-hearing children equated for age, sex and non-verbal IQ. The test consisted of 13 subtests which varied in stimulus complexity and verbal content. The subtests included letters, words, nonsense letter strings, forms and digits as stimuli. The subjects' task was to recall the maximum number of stimuli shown for a brief amount of time. Separate analyses of variance on the subtests data revealed that the normal-hearing children were better than the hearing-impaired children on nine out of 13 subtests and the older children were better than the younger children on all of the subtests. Doehring and Rosenstein computed partial correlations between each subtest and the IQ as measured by the WISC, and between each subtest and vocabulary skill as measured by the Peabody Picture Vocabulary Test, controlling for age. The results showed that for hearing-impaired students six out of seven perceptual subtests which required English language knowledge were significantly correlated with the Peabody Test. The WISC was not related to the subtests except for one subtest which involved word perception. Moreover, the WISC test was not related to the Peabody Test. In contrast, for normal-hearing children, the WISC was significantly related to the Peabody Test. Although the WISC and the Peabody Test were each related to some of the subtests, the correlations, in general, were low for normal-hearing children. Doehring and Rosenstein concluded that their results showed a significant relationship between "perceptual speed" and reading skill for hearing-impaired children. They suggested that these low correlations for normal-hearing children may have occurred because "the majority of normal-hearing children have passed the stage of learning in which reading achievement is partially dependent upon the mechanisms of visual search" (p. 125).

It appears from these interpretations that in both studies (Doehring & Rosenstein, 1969; Olson, 1967) an assumption is being made that the perceptual tests used are measuring some basic mechanism of visual perception; i.e., perceptual speed. Such an assumption is questionable since these perceptual tests, in general, used English language stimuli to measure "perceptual speed." Thus, the instruments to measure perceptual speed are confounded with language. How quickly the subjects recognized these stimuli may thus be directly influenced by knowledge of, and familiarity with, English language. The performance on these "perceptual tests" may then be related to English language tests because both tests are tapping the same skill. Therefore, the results of these studies are most simply interpreted as showing that the better their language skills, the quicker children are in recognizing linguistic information. It is inappropriate to draw any conclusions about the relationship between "perceptual speed" and English language skills.

A study which took into consideration the variables of familiarity and knowledge of English in measuring the relationship between visual perceptual skills and reading skill was conducted by Hartung (1970). He presented English trigrams and unfamiliar Greek trigrams at two exposure durations of either 187.5 or 312.5 milliseconds with a visual mask of 187.5 milliseconds following the trigram presentation. The subject's tasks were: (a) to determine if a particular letter appeared in each trigram, and (b) to reproduce the English trigrams. He then correlated the subject's scores on these tasks with the Gates-MacGinitie Reading Test of Vocabulary and Comprehension. Subjects were prelingually, severely hearing-impaired and normal-hearing children of average or better IQ, matched for age (7½ to 9 years). Performance of hearing-impaired and normal-hearing children was not different on identification of Greek trigrams which suggests that the groups did not differ in their basic visual perceptual performance when the information was unfamiliar to both groups. However, performance of hearing-impaired children on both identification and reproduction tasks involving English trigrams was significantly poorer than performance of normal-hearing children, which suggests that knowledge of English may have helped normal-hearing children more than hearing-impaired children in their performance. Trigram reproduction was correlated with reading skill for both hearing-impaired and normal-hearing children. Identification of *both* Greek and English letters correlated with reading skill for hearing-impaired subjects while only the English letter identification task correlated with reading skill for normal-hearing subjects. Hartung suggested that this pattern of results shows that "raw visual speed correlates with reading skill for the deaf, whereas only the speed on English letter tasks is so correlated in the normal hearing" (p. 607). These results are important since they suggest that perceptual factors other than knowledge of English may account for individual differences in reading skill of hearing-impaired people. However, it is not clear what type of perceptual skill is involved. Hartung considers it to be "visual speed," but it can very well be called "form discrimination skill" given the structure of the identification task.

Henderson and Henderson (1973) tested normal-hearing and hearing-impaired children (12.5 to 16.5 years in age) matched for age, sex, and nonverbal IQ, on a visual search task, and a tachistoscopic task which involved reporting consonants briefly shown. They found that the groups did not differ on the visual search task which required searching for a target letter in letter arrays containing capital and lower case letters, and were equally slowed down by the letter-name confusability. The hearing-impaired children did not differ from the normal-hearing on the tachistoscopic task at brief exposures, but at longer exposures they did worse than the normal-hearing children in recalling the consonants. These results suggest that although hearing-impaired and normal-hearing people may differ in their memory processes, they do not differ in their visual perceptual performance.

Mandes, Allen and Swisher (1971) tested congenitally, severely hearing-impaired and normal-hearing children (6.6 to 7.6 years of age) matched for age and visual acuity, on a tachistoscopic task. In each trial, eight circles were presented arranged horizontally or vertically in such a way that four appeared on the left and four on the right, or four appeared on the top and four on the bottom of the fixation point. One circle on each side of fixation was blackened for each card and the stimuli were presented at two exposure speeds, 1/10 second and 1/25 second. The subjects' task was to point to the positions of the black circles they saw on a response card after each presentation. The results showed that both groups made significantly less errors on the left half and the top half of the display than the right or the bottom half. The groups did not differ from each other, and the exposure duration did not significantly affect the performance. Mandes et al. interpreted the preference for the left and the top by both groups as due to scanning tendencies arising from the reading habits. Since the hearing-impaired and the normal-hearing groups did not differ from each other, they concluded that verbal mediation occurred in hearing-impaired children and this mediation influenced "verbal-like perceptual tasks." It is not clear why noticing circle positions would involve verbal mediation and is considered as a "verbal-like perceptual task." Furthermore, factors other than scanning tendency may have contributed to these results. For example, a right hemisphere superiority for dot patterns may have played a part in recognizing the left array more accurately than the right one.

Fitch, Sachs, and Marshall (1973) found no correlation between reading skill of hearing-impaired children (3 to 5 years of age) and their scores on the Frostig Developmental Test of Visual Perception, which is widely used to diagnose visual perceptual deficits. Their results are consistent with those by Colarusso, Martin, and Hartung (1975) who found no such relationship in normal-hearing children (5 to 7 years of age).

Siple, Hatfield, and Caccamise (1978) investigated the role of perceptual skills in learning sign language by testing post-secondary hearing-impaired students and normal-hearing new staff members at the National Technical Institute for the Deaf, on four tests of perceptual skills: the Closure Flexibility Test, the Flags Test, the Perceptual Speed Test, and the Closure Speed Test. They also gave the Manual Reception Test which measures proficiency in receiving signed English. The hearing-impaired students were separated into two groups according to their scores on the Manual Reception Test as High or Low manual groups. The staff did not know how to sign, initially. Siple et al. tested some of the students in the Low group and most of the staff again on all tests after these two groups had completed a course in simultaneous communication. Some of the students in the High manual group, who did not have to take the course, were also tested again. The results of the pre- and post-tests showed that the Closure Flexibility Test and the Perceptual Speed Test were significantly correlated with improvement in the Manual Reception Test performance of hearing-impaired students while the Spatial Manipulation Test and the Closure Speed Test were significantly correlated with improvement on the Manual Reception Test for the new staff members.

Siple et al. speculated that these results might indicate different strategies employed by the hearing-impaired and normal-hearing people in sign language perception, with hearing-impaired people analyzing the signs and normal-hearing people using a holistic (global) perceptual strategy during the early stage of sign language acquisition. Siple et al. also found that the hearing-impaired students as a group performed poorer on the Closure Flexibility Test than the normal-hearing group. These results are consistent with the Parasnis and Long (1979) results with the Group Embedded Figures Test (which is similar to the Closure Flexibility Test discussed earlier), which showed that hearing-impaired people were more field dependent than the hearing norm. Siple et al. also found that hearing-impaired students perform better on the Closure Speed Test compared to hearing people. These findings are consistent with the Furth and Mendez findings and suggest that hearing-impaired people may use a more global perceptual strategy in processing visual information compared to normal-hearing people. Thus, these results support the notion that perceptual strategy differences exist in hearing-impaired and normal-hearing people.

In summary, studies have not shown a strong relationship between specific visual perceptual skills and language skills, although there is some indication that an analytical/global perceptual strategy may be related to speechreading skill, and to improvement of sign skills in hearing-impaired people. Reading skill, as well as speechreading and sign skills, involve several different factors other than visual perceptual skills such as vocabulary, knowledge of language, memory, and comprehension skills. Because the language skill tests in these studies have generally measured the skill in understanding and recalling information, the influence of these cognitive factors may outweigh the perceptual factors in determining the performance on these tests. That is, pure visual perceptual skills may account for only a part of the variance in the tests generally used in the studies. In the future, an approach that takes into account the multiple factors involved in developing language skills is necessary to delineate the specific contribution of perceptual skills in development of language skills.

GENERAL CONCLUSIONS

In summary, the studies that have used visual perceptual tests to make inferences about the cognitive functioning of hearing-impaired people have not universally supported any of the three hypotheses; i.e., the perceptual deficit, the experiential deficit, or the perceptual compensation hypothesis. On tests that seem to require attending to the whole pattern (e.g., the Marble Board Test, the Pattern Reproduction Test, the Closure Speed Tests and the tests of good form and closure), hearing-impaired people perform better, while on tests that seem to require analysis of the pattern (e.g., the Picture Test, the Figure-Ground Test, the Closure Flexibility Test, and the Group Embedded Figures Test), they perform worse than normal-hearing people. These results indicate that hearing-impaired and normal-hearing people may differ in their use of an analytical/global perceptual strategy in processing visual information. In sorting multi-dimensional stimuli, hearing-impaired people seem to attend more to the dimension of color than form compared to normal-hearing people. This preference may be due to differences in perceptual strategies of hearing-impaired and normal-hearing people. There is some evidence for a significant relationship between an analytical/global perceptual strategy and speechreading skill, however, the studies have not yet systematically investigated this relationship or relationships between other specific visual perceptual skills and language skills. Such relationships may exist, but not be revealed until controls are developed to eliminate the influence of various other factors that affect performance on language skill tests such as vocabulary, grammar, and knowledge of context. Finally, many studies have various methodological and conceptual inadequacies which have seriously limited the validity or generalizability of their conclusions about the visual perceptual skills or the cognitive functioning of hearing-impaired people. Thus, this review underlines the need for more conceptually adequate and systematically designed research on visual perception in hearing-impaired people.

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