Central Auditory Dysfunction in Deaf Children

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We stress the probability in many cases of a common etiology for peripheral (i.e., sensory) and central disorders. Ferry (1978) listed such critical areas for research to prevent language disabilities in children as: asphyxia, hyperbilirubinemia, cytomegalovirus infection, and postnatal bacterial meningitis. One should add to that list the high risk factors recommended by the Joint Committee on Infant Hearing (1982). And, Brown (1983) listed several items to consider: genetics, hormones, microneuronal hypoplasia, nutrition, maternal infections, environmental pollutants, prenatal drugs, smoking and drinking, obstetric medication, obstetric trauma, and low birth weight.

From this extensive list of possibilities, we have been studying neonatal asphyxia for the last several years to determine how it influences peripheral and central auditory dysfunction. One of the things we have found is that, although it is widely accepted that oxygen deprivation can result in various deficits, the degree of the oxygen/carbon-dioxide imbalance sufficient to result in asphyxia has not been adequately determined. Furthermore, researchers have shown a lack of careful definition; generally, the literature reveals that the terms asphyxia, anoxia, and hypoxia are used interchangeably. Graham and her colleagues (1962) found that the measurement of blood oxygen was the least reliable method to employ to define asphyxia. Pappas (1983), as well as many others, proposed using arterial pH measurements to determine if an asphyxia condition exists. In fact, at one of the earlier Elk's symposia it was stated that an arterial pH of less than 7.3 has been associated with an increased risk of hearing loss. Nevertheless, the recommendations of the second symposium (Gerber & Mencher, 1978) still did not include a specific pH level to be used to determine asphyxia. Consequently, in all of our research, we have used a very broad and loose definition of asphyxia: any need for assisted ventilation in the immediate neonatal period.

At no time have we suggested that asphyxia is necessarily, or even probably, the cause of any specific speech, language, or auditory difficulty. Our purpose has been to ask whether children who have such a history differ in measurable and important ways from those who do not. Further, in 1980, Gerber reported that 10% of a group of 190 speech or language disordered children had had a need for assisted ventilation as neonates. A year later, D'Souza and his associates found an incidence rate of language delays of over 20% in a group of school-aged children with birth histories which included asphyxia. Later, Gerber, Prutting, and Wile (1983) reported results of a pilot study suggestive of increased language difficulty in a group of asphyxiated deaf children. Recently, Hubatch et al. (1985) found that children with a history of respiratory distress were inferior to controls on measures of receptive language.

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Experiment I

In a first study (Wile, 1984), we sought to determine if the language skills of children with severe to profound hearing impairments with a reported history of neonatal asphyxia differed from those of congenitally deaf children with no such history.

In two previous Elks' symposia, Robertson (1978) and Robertson and Whyte (1983) reported neonatal asphyxia as a frequent cause of congenital hearing loss. Mencher, Baldursson, and Mencher (1981) also have reported neonatal asphyxia as a cause of auditory dysfunction. Since all of these studies have reported the suspicion that it may also cause language dysfunction in the presence of apparently normal hearing, the question was asked whether neonatally asphyxiated deaf children differ from other congenitally deaf children in their language skillls.

Subjects for the study were 12 severely to profoundly hearing impaired children between the ages of 6 and 10:8 years. All were in total communication public school programs, and all employed total communication in both home and school. None of the subjects exhibited handicaps other than those presented by the hearing impairment, and all had non-verbal IQ scores in the normal range. Six Ss had a history of neonatal asphyxia; six did not. Ss were matched by age and degree of hearing loss. All 12 children had bilateral hearing losses in excess of 70 dB HL in the better ear; most exceeded 90 dB. All 12 Ss wore binaural amplification, none wore eye glasses. All used Signing Exact English (SEE II) as the primary means of communication.

All assessment materials were adapted from the Clinical Evaluation of Language Functions test, the CELF (Semel and Wiig, 1980). Our 1983 (Gerber, Prutting, & Wile) study indicated that specific sub-tests of the CELF may serve to differentiate between neonatally asphyxiated congenitally deaf and other congenitally deaf children. Thus, only two sub-tests were used: Processing Word and Sentence Structure and Producing Names on

Confrontation. A significant adaptation of the CELF for our purpose was that all items were presented simultaneously voiced and signed in SEE II.

The first of the CELF sub-tests is intended to "assess the child's ability to process and interpret selected word and sentence structures" (Semel and Wiig, 1980). The child is presented with a test item and required to point to one of four pictures to indicate a response. The other sub-test (Producing Names on Confrontation) is designed to investigate a child's ability to accurately and quickly label colors and shapes. We varied the standard procedure for this sub-test to require the child to label only the color, only the shape, and then both. This is a timed test which was given in its entirety. The children were asked to respond using sign language. All of the children successfully completed the items, thereby indicating they knew the names of the colors and shapes.

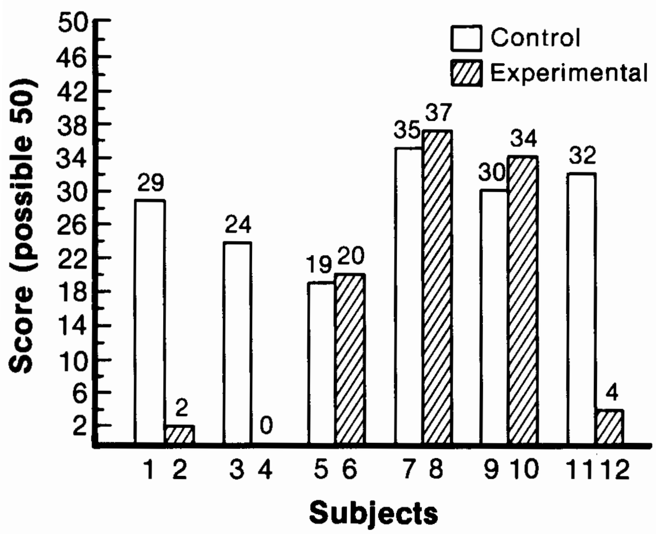

Figure 1: Processing word and sentence structure.

Figure 1 shows the number of correct responses, among a possible 50 items, on the test for processing word and sentence structure. Three of the six non-asphyxiated children scored higher than their asphyxiated partners, and three scored lower. However, for those pairs where the asphyxiated children scored higher, the difference never exceeded four points; whereas in the other pairs, the difference always exceeded 24 points. Overall, the non-asphyxiated children had a mean score of about 28 and the experimental group averaged about 16. In our opinion, this mean difference of 12 points suggests that asphyxiated children may have greater difficulty with receptive language. Furthermore, the standard deviation for the scores of the asphyxiated children was about 15 while it was just over five for the other children. Granted, the number of subjects is small, but the trend is clear. Not only did the non-asphyxiated children do better as a group, they also displayed less variability.

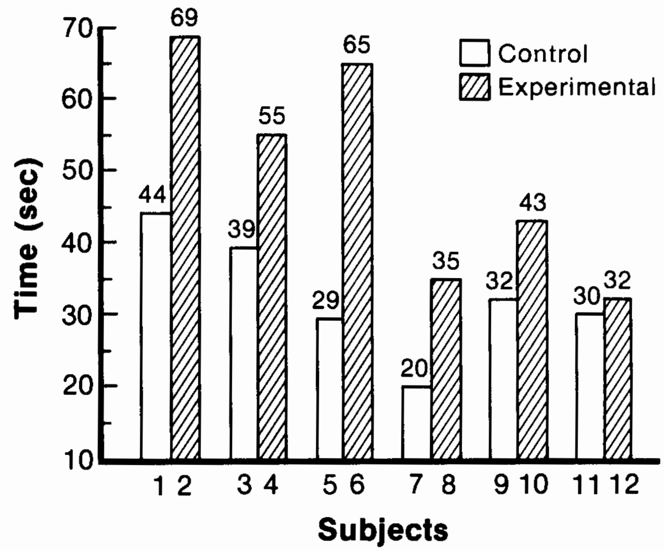

Figure 2: Producing names on confrontation; color only.

Figure 2 shows the time required on the second sub-test to identify only the color of the stimulus picture. Mean times for the non-asphyxiated children were about 32 seconds, while the asphyxiated children had a mean time of about 50 seconds. No child in either group misnamed more than one item. In other words, while all 12 of the children knew the names of the colors, it took considerably longer for those with a history of asphyxia to report the name. Again, the standard deviation for the asphyxiated group was larger than for the others; namely; about 14 seconds as compared to somewhat less than eight seconds. So, not only are they slower, again they are more variable.

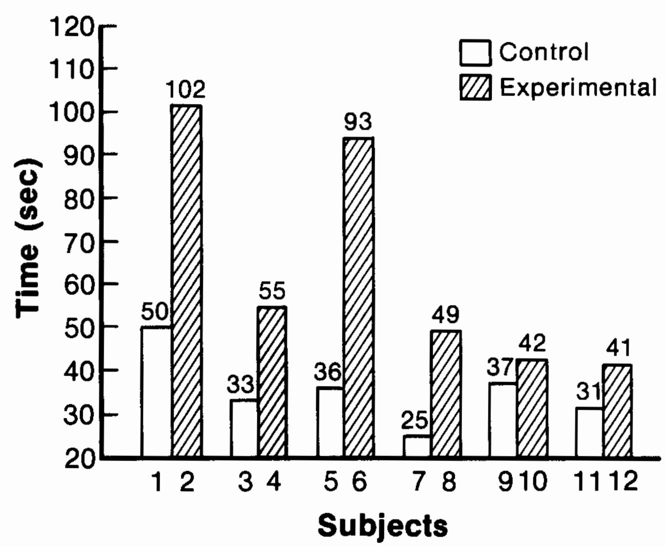

Figure 3: Producing names on confrontation; shape only.

When we asked them to identify only the shape (Figure 3), they again took longer to do it: 64 ± 24 seconds as compared to 35 ± 8. Again, these scores indicate slower processing times and increased variability for the children with a history of neonatal asphyxia.

When we asked them to identify both the color and the shape (Figure 4), the non-asphyxiated children had a mean time of about 73 seconds with a standard deviation of not quite 18 seconds, while the asphyxiated children had a mean time of 130 seconds and a standard deviation of 50 seconds. Notice that the fastest of them (#12) took nearly a minute and a half to respond.

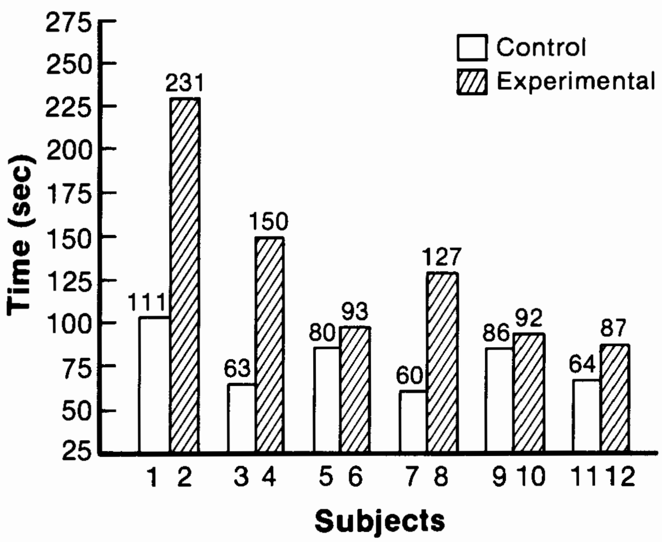

Figure 4: Producing names on confrontation; color and shape.

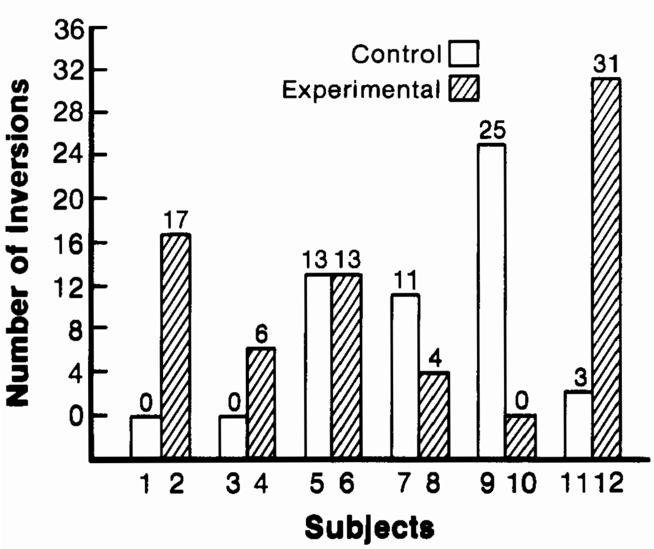

Figure 5: Number of inversions.

The next figure (Figure 5) indicates something surprising. Normal English syntax, including SEE II, requires that the name of the color precede the name of the shape; that is, we say "red circle" not "circle red". Notice, however, the rather large number of inversions (that is, shape before color) for all but one of the asphyxiated children and all but two of the others. So, even though they may be correct at identifying, syntax was a problem even for two word combinations. We suppose this is an effect of deaf language, and perhaps this should be studied further.

What can we conclude from Experiment I? First, that the language skills of some profoundly hearing impaired children who have a reported history of neonatal asphyxia seem to be poorer than those of other congenitally deaf children. There is also increased variability within the asphyxiated. These differences suggest there may be value in the employment of different educational strategies for these children. For example, instruction in ASL may turn out to be more effective than in SEE. Or, a heavier emphasis on manual communication — even at the expense of oral/aural communication — may become necessary.

One must appeal to the notion espoused by Knobloch and Pasamanick (1959) that there is a "continuum of reproductive causality." Certainly, we have witnessed that, and one should not expect a one-to-one correspondence among asphyxia, hearing impairment, and language disability.

Experiment II

The data just presented suggest one difficulty frequently, but not consistently, associated with hearing loss and neonatal asphyxia is some kind of language disability. But it is possible that what we have seen is not a specific language dysfunction, but rather some kind of intellectual, cognitive, or learning dysfunction. Studies linking neonatal asphyxia and later cognitive deficits have generally used intelligence test scores for comparison. For example, Hamai (1984) attempted to reveal the relationship between neonatal asphyxia and specific cognitive abilities among hearing impaired children. She employed six of the 12 children who had been used by Wile, three of them with a history of asphyxia and three without. The general test procedure was the same as that outlined in Experiment I. The assessment materials utilized in this study consisted of four sub-scales of the Hiskey-Nebraska Test of Learning Aptitude (H-NTLA). Hiskey (1966) described this as a test of "mental ability designed specifically for acoustically handicapped children and standardized upon them." It has been a commonly used assessment tool for the deaf population for many years. Each sub-scale of the H-NTLA is a series of performance tasks arranged in ascending order of difficulty. She selected those sections of the test she believed assess a number of different processes: picture identification, picture association, visual attention span, and completion of drawings (See Appendix I).

All raw scores obtained from the subjects were converted to learning scores utilizing the norms for deaf children provided with the H-NTLA. It is important to note that Hiskey has always insisted that the test does not measure intelligence and does not render an IQ. Instead, the test score results in a "learning age" which means that a given child is able to do the same tasks or solve problems with the same efficiency as the average deaf child of that age. What is important about the Hiskey test is that it compares deaf children with each other. For purposes of making such comparisons in this study, the performances of the asphyxiated subjects were compared with those of matched deaf controls by subtracting each subject's chronological age from his or her learning age for each of the four sub-scales. The resulting difference score, then, is expressed in months. A positive score indicates that that subject is functioning that number of months above chronological age on that sub-scale; a negative score indicates that the child is functioning below chronological age by that number of months.

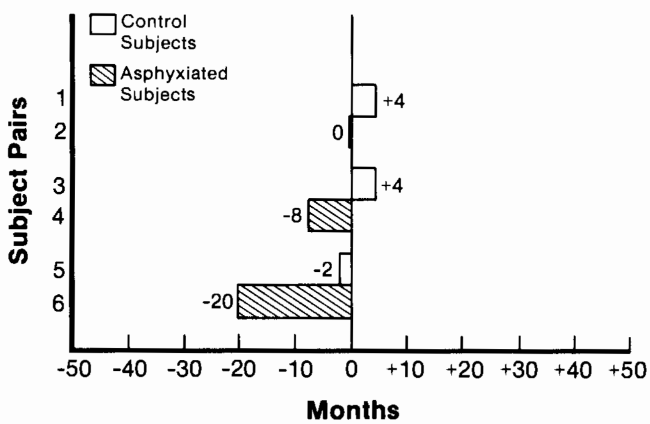

Figure 6: Difference between median age rating and chronological age (in months).

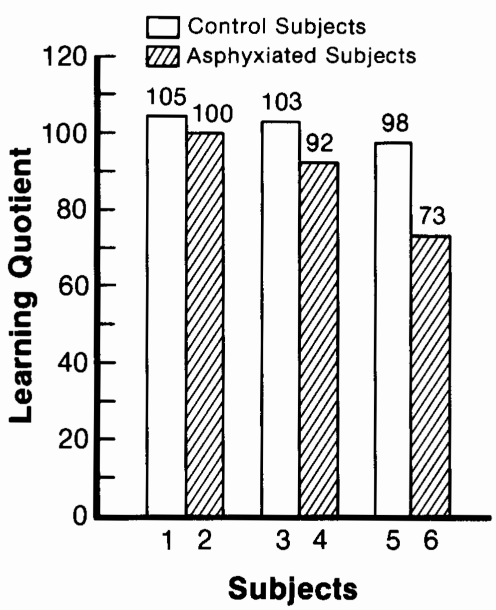

Figure 7: Learning quotients.

Figure 6 expresses the median age ratings for each subject pair and the difference between that rating and the children's chronological ages. In each pair, the non-asphyxiated subject had a higher difference score than the matched subject. All of the subjects with a history of neonatal asphyxia performed at or below age level, and two of the three did so by more than six months. The children without a history of asphyxia performed either above chronological age or very slightly below, four months above and two months below.

Figure 7 shows learning quotients as derived from Hiskey's notion of learning age. In each of the pairs, the asphyxiated child had a lower learning quotient than his peer; however, all but one are clearly normal. This evident normalcy is not so evident if we examine the separate tasks. Figure 8 illustrates each subject's difference score for the picture identification task. This time the control subjects scored higher than their asphyxiated peers in every pair (by as much as 64 months). The difference is not as marked in the case of picture association (Figure 9) where we see that one of the non-asphyxiated controls (#3) also did not do well. Still, the subjects with a history of asphyxia did render lower scores than their counterparts.

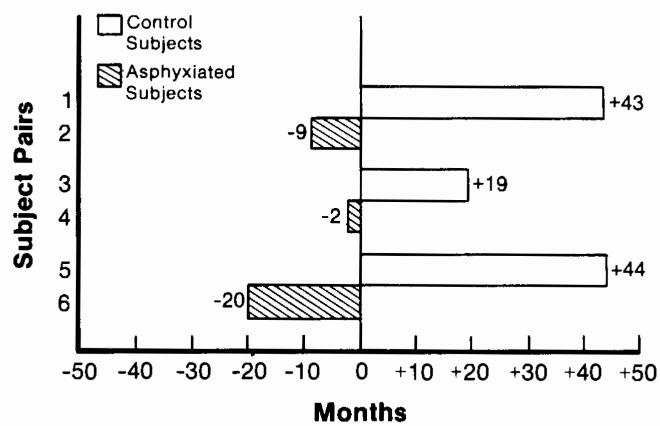

Figure 8: Picture identification difference between learning age and chronological age (in months).

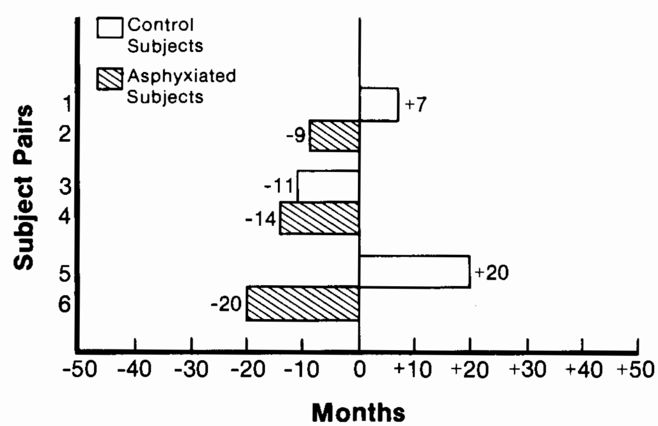

Figure 9: Picture association; difference between learning age and chronological age (in months).

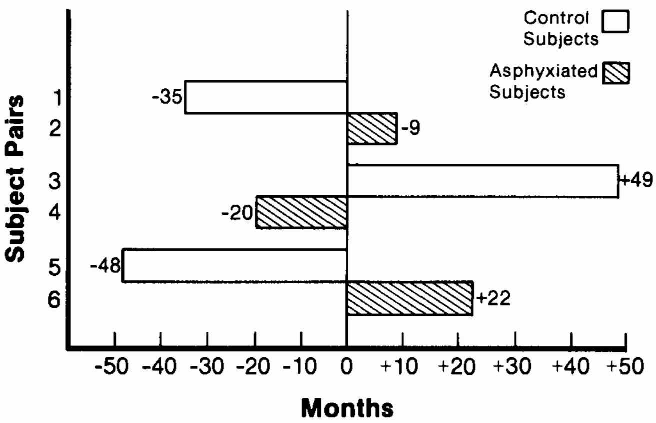

Figure 10: Visual attention; difference between learning age and chronological age (in months).

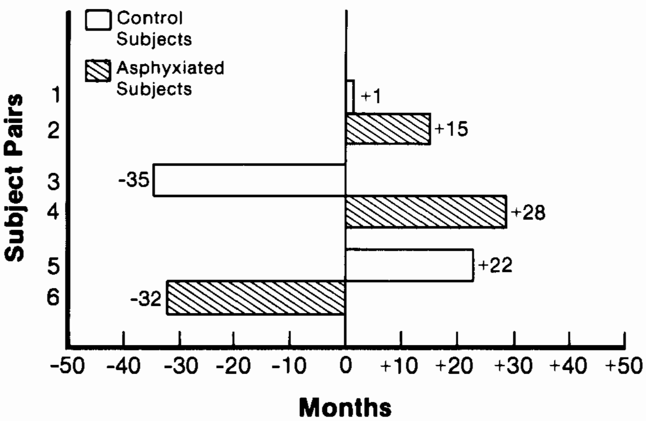

Figure 11: Completion of drawings; difference between learning age and chronological age (in months).

On the sub-scale intended to measure visual attention span, two of the asphyxiated children scored better than their peers (Figure 10) as they did on the completion of drawings (Figure 11), but they weren't the same two.

Calculation of the median age scores and the learning quotients indicated that the subjects with a history of neonatal asphyxia generally scored lower than the controls on the H-NTLA. This was true both when the children were compared as groups and as matched pairs. If we examine the performance of each subject, we find that none scored consistently higher or lower across all sub-scales. The age of the subject did not appear to have an effect on the sub-scale scores. Of course, the number utilized in this experiment is quite small; therefore, the subject by subject match is more important than group data. Furthermore, everything should be replicated.

What can we conclude from Experiment II? Asphyxiated subjects, while scoring at or above age level on some H-NTLA sub-scales, scored below age level on others; thus, the overall score does not reflect poor performance. Yet, school aged deaf children with a history of neonatal asphyxia did perform poorer than matched controls on tests which measure visual association, discrimination, matching ability, and conceptual knowledge. These data suggest that the asphyxiated subjects did not suffer from a generalized learning deficit, but instead may have exhibited deficits of specific abilities which are not necessarily language abilities. The asphyxiated subjects had lower performance on picture identification and picture association, but were different from each other on visual attention span and completion of drawings. Thus, it may appear that abilities sampled by the picture identification and picture association tests are subject to disturbance by asphyxia at birth.

General Conclusions

We offer a hypothesis that the presence of asphyxia at birth in deaf children is related to the subsequent development of difficulties in visual discrimination, especially of fine detail. Clearly, there is an association between these presumed deficits of visual discrimination and deficits of linguistic performance. Deaf children must rely, primarily, on visual means — i.e., sign language and speech reading — to gain knowledge of the world and to grow linguistically. It may not be surprising, therefore, that asphyxiated deaf do not perform as well as deaf children without a history of asphyxia on linguistic measures.

There is a basis for assumptions about relative failures of visual processing in aurally or linguistically impaired children. Stark, Mellits, and Tallal (1983) observed that language delayed children were poorer than normals on tests of visual sequencing, among others. Furthermore, hearing impairment per se is not the only relevant factor. Seewald et al. (1985) concluded that "...some factor other than average hearing level contributed to the relative use of audition or vision in speech perception." The findings from these two studies, as well as from our earlier work and the recent paper of Hubatch et al. (1985), continue to point to some kind of central processing deficit in children who have experienced asphyxia at the earliest time of life. Whether this deficit is expressly linguistic, generally cognitive, a combination of them, or something else is not yet determined. Nevertheless, there are indications that there is some kind of central processing dysfunction which sets apart these deaf children from other congenitally deaf children. That means educational considerations need to be modified for them.

Acknowledgement

The devotion of Beth Wile and Nancy Hamai to this work extended far beyond that normally expected of graduate students. They travelled literally the length of California — from Riverside to Chico — to find only 12 children who could and would qualify as subjects for this research. Also, Beth Wile is the "fluent signer" mentioned in the text.

Appendix I

Subtests selected from the Hiskey-Nebraska Test of Learning Aptitude and the abilities assessed by each sub-test (Hiskey, 1966)

Subtest	Abilities Assessed
Picture Identification	Visual discrimination and matching; analysis of visual detail.
Picture Association	Visual association; awareness of the environment; concept relationships.
Visual Attention Span	Visual sequential memory; continued concentration
Completion of Drawings	Visual analysis and closure; conceptual knowledge; visual concentration.

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