Critical learning period for speech acquisition and screening techniques in early detection of hearing impairment

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In order to develop verbal communication skills, an infant nervous system needs sound stimuli, especially human speech, in the early and critical learning period of life. The maturation of hearing and language learning abilites of an infant is considered to be complete within the first two to three years of life. Therefore, detection of hearing impairment before the end of the critical language learning period is considered crucial if a child is expected to acquire his/her native language properly. Parents or caregivers may suspect the presence of a delay in language acquisition; however, relying only on parental awareness could cause a delay in detection of the hearing impairment. Even mild hearing loss may interfere with normal development of speech and language in infants, therefore, universal screening of infants for hearing loss as early as possible should be the goal.

The purpose of this paper is to discuss the concept of the critical language learning period and its relevance to language acquisition. Furthermore, it is the aim of the paper to evaluate the available techniques for early identification of hearing impairment in general and the feasibility of the various techniques in Turkey.

Key words: newborn, congenital, sensorineural, hearing loss, deafness, early identification, language, newborn hearing screening.

Hearing impairment seems to be one of the most common diseases in the world. According to statistics, this is even true in a highly developed country such as the United States of America, where hearing impairment in general is considered second only to arthritis as the most prevalent chronic disease. In fact, the incidence of children born with mild to profound degrees of permanent hearing loss in the United States is at least 1 in 750[1].

Although there are several types of disabling conditions, among these, hearing loss in the early period of life is considered to be a unique problem. Parents can recognize the problems of a blind infant at once but it is not easy to recognize a congenital hearing loss. Late identification of infant hearing impairment is considered a major public health problem. The purpose of this paper is to review the reasons for early identification of hearing impairment in general and the feasibility of the techniques for detecting hearing impairment in Turkey.

1. Hearing Impairment and Language Disability

There is common agreement that congenital hearing loss inevitably leads to some type of language learning disability. According to Bamford and Saunders[2], poor language performance related with congenital sensorineural hearing loss comes about not only because of lack of sensory input (e.g. speech sounds) -the primary cause- but also because of associated secondary effects. The secondary effects have been described as "contextual aspects of language acquisition". Again, according to the same authors, contextual aspects of language acquisition can be divided into two main processes.

The first process is the internal contextual aspects of language development, which are concerned with cognitive processes and strategies. Cognitive processes are involved with the intelligence and may be defined as an ability to recognize relationships and solve problems. In the past, it was thought that intelligence was mainly determined by heredity. However, it is

now felt that intelligence (at least cognitive processes) is partly determined by the sensory inputs a child receives.

The second type of contextual process involves the outside world of the infant, such as adult-child interactions and the communicative abilities of the infant. These abilities are mainly needed for adaptation of the infant to the social environment. The main cause of several psychological disorders of the child, indeed, may be related to insufficient adaptation of the child. In fact, it is reasonably easy to discover the relationship between hearing loss and psychodynamic factors in the childhood period. Thus, although the hearing loss seems to be limited to his/her ears, the child's total life is affected by this condition.

2. The Critical Learning Period

The maturation of hearing and language learning abilities of the infant is essentially completed within the first two to three years of life. In fact, these skills, which are highly integrated, start to develop as soon as the child is born. Thus, it is almost a consensus that in order to develop communication skills, an infant nervous system needs sound stimuli, essentially the human speech, in the early and critical learning period of life. In a study of adopted children, Dennis[3] identified the first two years of life as the critical period for exposure to a good language environment.

Actually, the critical period of speech acquisition is a maturational concept and does not help to illustrate the deficient part of the nervous system. On an anatomical basis, Rubin[4] argued for the early plasticity of the brain. The brain requires stimulation in the first three years of life, if auditory perception and language acquisition are to occur:

".... Available information would indicate that the maturation of the auditory system is centripetal, proceeding from cochlea to the auditory cortex. Environmental sounds would appear to have its greatest effect in shaping auditory ability from the time the cochlea and eighth nerve first become functional (i.e. just after the birth) to the time when maturation of the central nervous system is achieved."

There are controlled studies on the hearing-impaired population that seem to support the concept of early plasticity of the brain. For instance, in an earlier study, the Lexington School for the Deaf[8] compared infants who had been admitted to the audiological habilitation program before 16 months of age with those admitted between 16 and 24 months. After the habilitation program had been carried out, the results showed that mother-infant communication was far more superior in the earlier admitted group. In addition, the language learning abilities of these children were higher than those of the late admitted group. The lower age limit for the language acquisition period could be as early as six months[6]. According to recent studies which compared early intervention versus intervention after six months, the hearing-impaired infants who received early recognition as well as early habilitation were far more superior in terms of receptive as well as expressive language abilities[7].

3. Parental Awareness

One of the main targets could be to develop parental awareness for hearing impairment all over the country. This effort may not be sufficient to detect hearing impairment within the first 12 months of life; however, it may lower the overall age of detection of hearing impairment and help to improve the services supplied to these children. Parents could recognize the hearing impairment earlier than anyone else, if they are properly informed. Since it is difficult to inform parents individually, mass media could be used to make parents conscious and possibly suspicious about their child's hearing and language learning problems.

Generally, only parents can be sure of their child's hearing loss at a time when there is an obvious delay in speech production. This is probably related to the observation that parents as well as medical professionals are mainly concerned with only the delay in speech production. Tucker and Nolan[8] also reported that parental detection of hearing loss is 70 percent successful. Unfortunately, this detection is often dependent upon concern at the lack of language development[8] which, by definition, occurs too late for remedial action to be taken (see the section above). On the other hand, hearing loss can be detected early if the simple reactions of an infant to a ordinary speech signal are considered as the criteria of normal hearing, instead of speech acquisition.

According to a study of deafness in the European Community[9], only 22 percent of affected children were suspected by their parents

of being hearing-impaired in the first year of life and only about two-thirds by the time they reached their third birthday. This is an another example which indicates that it is not an easy task to detect hearing impairment before children reach the end of the critical language learning period, if we relied only on parental awareness.

4. Screening Methods for Hearing Impairment

A traditional definition of screening is "a process of applying to large numbers of individuals certain rapid, simple measures that will identify those individuals with high probability of disorders in the function tested"[10].

If a very young child has suffered some sort of hearing loss or any kind of mental retardation or cannot participate in a familial language environment, the central nervous and auditory systems will not develop correctly. Of these adverse conditions which might lead to some sort of deviation in the normal development of language acquisition, congenital hearing loss can be detected within the first three days of life. Thus, in terms of screening criteria, the screening of congenital hearing loss in infants is considered as acceptable and feasible. In the search of a technique for screening hearing in the infant population, the main difficulty is that there is no established rapid, simple and perfect measure to employ all over Turkey. There are some types of subjective and objective hearing tests which can be used. However, in the newborn population, only objective measures can essentially provide a rapid, simple and perfect detection of hearing loss[12].

Recent technological developments have produced objective screening methods that are rapid, reliable, sensitive, and easily administered. These advances offer an opportunity, for the first time, to initiate universal screening for hearing impairment in early infancy. Objective screening tools are becoming more and more popular and are almost acknowledged as routine hearing screening tests[8]. Two objective measuring techniques, auditory brainstem response (ABR) and transiently evoked oto-acoustic emission (TEOAE), are currently available and used for infant hearing screening. ABR is the most reliable measure currently available with which to assess the functional integrity of a child's peripheral auditory system. while ABR can estimate the degree of hearing loss if peresent, it is time consuming and requires experienced personnel. In order to decrease the time required as well as the qualification of the personnel, an automated measurement of ABR has been developed[11]. In the latter study, 41,000 newborns screened using automated ABR equipment as well as a TEOAE device improved the screening results to near 100 percent sensitivity and an as low as 2 percent false-positive rate. However, such successful results need to be replicated by other researchers in order to be convincing. The TEOAE technique, on the other hand, has been proposed as an objective, rapid and noninvasive screening test for auditory dysfunction in neonates. This technique is sensitive to cochlear hearing losses and provides "pass or refer" results. The Joint Committee on Infant Hearing stated on June 21, 1994 that even mild hearing loss may interfere with normal development of speech and language, and recommended the goal of universal detection of infants with hearing loss as early as possible. This committee endorsed the goal of identification of hearing impairment using two-stage screening (i.e. initially applying TEOAE testing and then utilizing ABR technique for those infants who failed the first stage) before discharging from the newborn nursery[12]. Both of these screening techniques satisfy all the necessary criteria required for screening the infant population. In a paper to be published soon, the results of a two stage screening program applied by the author and colleagues in 100 neonates with high-risk in a Neonatal Intensive Care Unit in İzmir revealed a hearing loss rate in the high-risk group in Turkey in the range of 13 percent which was higher than expected.

5. Screening High-Risk Infants

High-risk infants can be described as a small group of children whose history and physical conditions identify them as possessing a high chance of having the handicap searched for. Since the incidence of moderate to profound hearing loss in this high-risk group is fairly high (i.e. 2.5 to 5%), full audiological testing of this group is required, once this group has been identified (see Appendix I). In the past, as screening the entire newborn population (universal screening) is expensive (in terms of expenditure and human resources), screening

only risk newborns was considered sufficient[13]. However, screening only the infants with high-risk criteria identifies only half of the infants with significant hearing loss, and the other half of the infants with hearing loss (which are not within the high-risk population group), would be detected as having hearing loss later than the age of two years. Thus, it is envisaged that screening high-risk infants would not achieve the goal of detecting hearing loss before the end of the critical language learning period.

6. Universal Screening

In the United States of America, which is one of the leading countries in terms of health and technology, there is a tendency to apply universal screening in the first months of life. In the United Kingdom, the Health Visitor Screening Program has been developed. This type of universal hearing screening test is routinely carried out on nine-month-old babies in some regions of the U.K., by specially trained Health Visitors employing behavioral distraction tests[8]. This kind of screening test, while adventageous in that the whole hearing pathway is tested, is not considered an appropriate technique for Turkey, since it relies heavily on highly trained and experienced staff.

In 1993, The National Institutes of Health in the U.S.A. issued a statement on Early Identification of Hearing Impairment, and concluded that "significantly reduced auditory input also adversely affects the developing auditory nervous system and can have harmful effects on social, emotional, cognitive, and academic development, as well as on a person's vocational and economic potential[14]. 'This panel endorsed the recommendations of the Joint Committee on Infant Hearing that all hearing-impaired infants should be identified and treatment initiated by six months of age. In order to achieve this objective, the latter panel recommended universal screening for hearing impairment prior to three months of age. Because of the unique accessibility of almost all infants in the newborn nursery, the consensus panel recommended screening of all newborns, both high and low-risk, for hearing impairment prior to hospital discharge. Clearly, universal screening will increase the number of infants identified with hearing impairment. This will necessitate adequate diagnostic follow-up and treatment facilities. Comprehensive intervention and management programs (i.e. audiological rehabilitation and special education centers) must be an integral part of a universal screening program. Thus, universal newborn screening is only the initial step if early detection and intervention are considered the target of the public health policy in this country.

Because 20-30 percent of hearing-impaired infants will acquire their hearing loss during early childhood, universal neonatal screening is not a replacement for ongoing surveillance throughout infancy and early childhood. Even though universal screening is an essential step in the early detection of hearing impairment, education of primary caregivers and primary health care providers on early signs of hearing impairment remains an important goal.

Conclusion

The infant nervous system is extremely sensitive to human communication sounds, especially at the beginning of life. If the infant cannot participate in a familial language environment or suffers from some type of hearing impairment during the first three years of life, then the speech and language learning abilities of the child will be inevitably affected. As the mental and psychological development of the infant is closely dependent on communication the infant is generally affected by these conditions. However, if the main reason for interruption in communication is analyzed, and remedial action can be taken before it is too late, the development of the child will be minimally affected. In other words, "the earlier, the better".

In the past, detection of hearing impairment was often dependent upon concern at the lack of language development. According to current concepts, it is not a sufficient way to detect hearing impairment, especially if the mental and psychological development of the child, have been affected.

To deal with congenitally hearing-impaired children, team work is necessary. Various groups of people should coordinate in order to organize better screening programs: parents of hearing-impaired infants, audiologists, physicians, teachers, psychologists and so on.

In an ideal large-screening program, it is assumed that all infants will be checked for hearing impairment, i.e. universal hearing

screening. If the universal hearing screening is not considered feasible, then audiological evaluation of high-risk infants should be done.

Consequently, there is widespread agreement about the need for very early identification of a child suffering from congenital hearing impairment. It is difficult, to cure congenital sensorineural hearing impairment. However, if it can be recognized earlier, children suffering from hearing impairment can be habilitated and specially educated, only then minimizing the damaging effects.

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