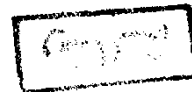


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DEVELOPMENT AND STANDARDIZATION OF
ARABIC LANGUAGE CENTRAL
AUDITORY TESTS

*A Thesis Submitted To The
Division Of Graduate Studies
And Research
University Of Ain Shams*

*In Partial Fulfillment Of
The Requirements For The
Degree Doctor of Medicine
In Audiology*



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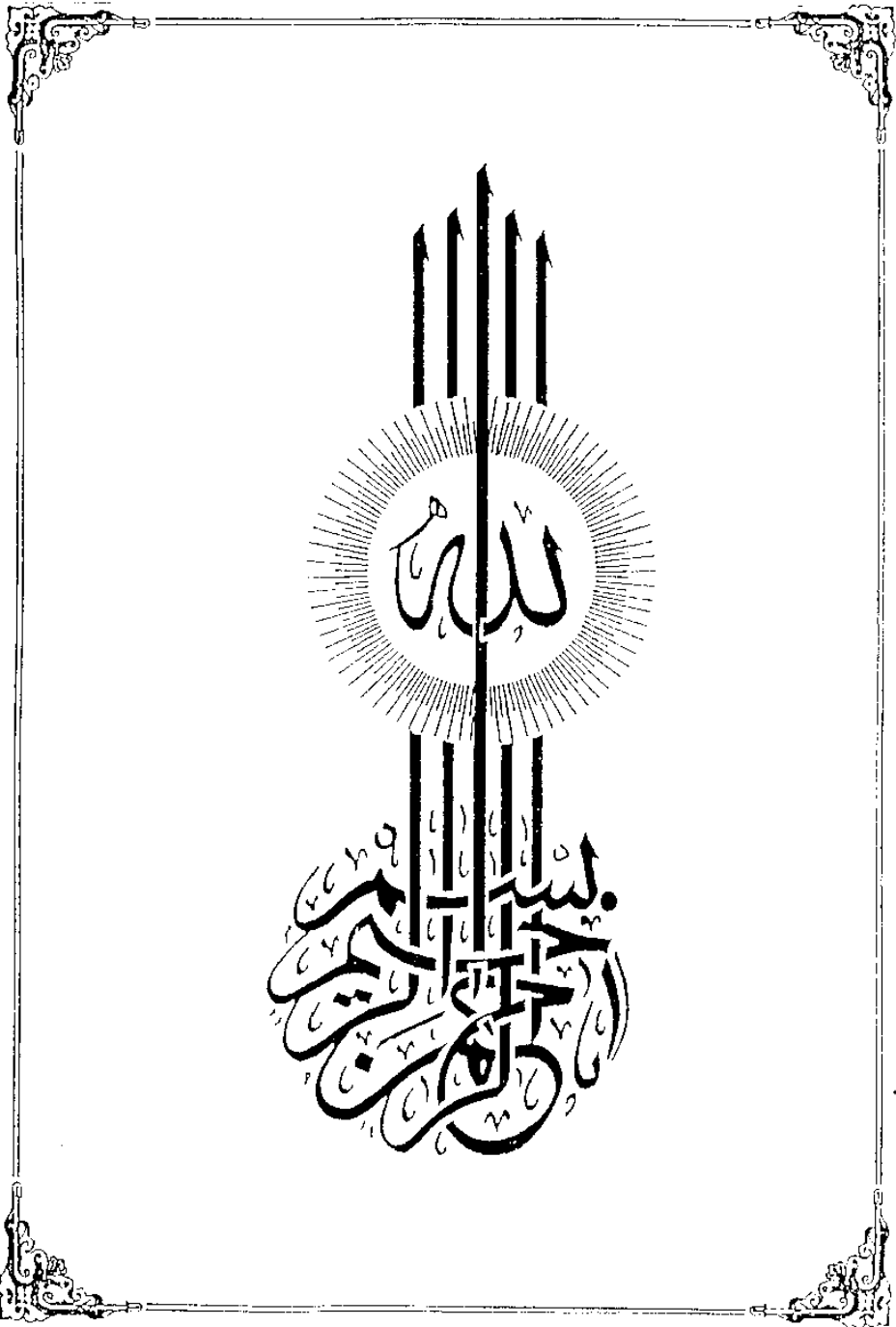
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Introduction

For many years the field of audiology has been associated with problems of the ear and the medical speciality of otology. While the ear is unquestionably a most vital aspect, the concept of audiology is a broad term referring to the study of the entire auditory process including external and middle ear, cochlea, the cochlear nerve and the central auditory pathways (Katz and Weisberg, 1978). Interest in the evaluation of central auditory lesions reflects the extension of audiology beyond the borders of middle ear, cochlea and cochlear nerve (Spitzer, 1983).

Traditional audiological tests have been shown to be valid and reliable methods of evaluating the auditory system. Unfortunately, these standard tests primarily evaluate the peripheral auditory mechanisms but cannot detect the more subtle deficiencies of auditory functioning in many patients with brain lesion and learning disabilities (Willeford and Billger, 1979).

Central hearing tests have an increasingly valuable role in auditory diagnosis including the basic investigation of the central auditory nervous system, the localization of disorders of the auditory pathways and the determination of auditory perceptual problems in children (Keith, 1982). Hence, it was necessary to develop specially designed tests for evaluating central auditory function.

Central auditory pathways:

The development of a clinically applicable technique for the evaluation of hearing impairment produced by lesions of the central auditory pathways has increased clinical interest in the anatomy and physiology of these pathways (Snow, 1966). Knowledge of these pathways is basic to the understanding of the neurological aspects of central auditory mechanisms (Duane, 1977).

The central auditory nervous system can be described as a complex and diffuse system of interconnecting neural pathways with afferent and efferent connections between cochlea and cortex (Keith, 1982). That is, the Central auditory pathways may be defined as that portion of the total auditory system lying within the central nervous system (Jerger, 1973). This includes chiefly the brain stem pathways (Jungert, 1958) and the primary auditory projections on the superior temporal gyri (Tunturi, 1960).

The auditory pathways are either afferent (ascending) from the cochlea towards the cortex or efferent (descending) from the higher centers to the periphery. The afferent auditory pathways commence with the cochlear nerve that passes through the internal auditory canal and then enters the brain stem at the junction of cerebellum, medulla, and pons to form the cerebellopontine angle (Matzker & Folz, 1972; Whitfield, 1967). It divides into ascending and descending branches, which run to the ventral and dorsal cochlear nuclei where cell bodies give rise to second order neurons. Anatomical data indicate an orderly projection of the cochlear partition in each of the areas of the cochlear

nuclei. Incoming fibers from the eighth nerve bifurcate into ascending and descending branches; the ascending branches innervate the anterior ventral cochlear nuclei, while the descending branches innervate the posterior ventral cochlear nuclei and dorsal nuclei. Thus, apical fibers terminate rostrally and ventrally, while basal fibers terminate caudally and dorsally (Larson and Pfingest, 1982)

All eighth nerve fibers synapse on cells in the cochlear nucleus. Thus, the cochlear nucleus is considered as an obligatory synapse, in contrast with some other nuclei at which incoming fibers may either synapse or pass through to synapse on other nuclei higher in the auditory pathway.

After synapsis in the cochlear nuclei, the majority of second order neurons decussate to terminate in the opposite superior olivary complex, mainly in the medial olive. The fibers decussate in three distinctive striae: a dorsal acoustic stria (stria of Monakow), an intermediate stria (stria of Held), and a ventral acoustic stria known as the trapezoid body which is the largest of the three. Some fibers of the second neuron ascend to the superior olive of the same side. The superior olive is considered as the first place in the ascending auditory pathways to receive acoustic information from both ears (Lynn and Gilroy, 1976). This means that fibers from each ear synapse in both ipsilateral and contralateral superior olives, but the latter is the dominant tract in terms of number of fibers (Lynn and Gilroy, 1976). The superior olive is an auditory relay center as well as an auditory reflex center (Talmage, 1977).

The third order fibers that arise from the superior olive

ascend in the lateral lemniscus to terminate in the inferior colliculus. The lateral lemniscus receives second order fibers from the contralateral cochlear nuclei as well as third order fibers from the ipsilateral and contralateral superior olive (Beasley and Rintelman, 1979). A large number of fibers in the lateral lemniscus pass the nucleus of the lateral lemniscus and ascend to terminate in the inferior colliculus. A few fibers terminate at the nucleus of the lateral lemniscus and give fourth order neurons. A minor number of fibers cross over to the contralateral lateral lemniscus and its nucleus. Crossing occurs along a commissure called the Commisure of Probst. This produces another means for bilateral presentation of each cochlea in the higher auditory centers (Talmage, 1977). The fibers synapse in the inferior colliculus at the mid brain level. The inferior colliculus receives second order, third order, and fourth order contralateral and ipsilateral auditory pathway fibers. The inferior colliculus constitutes an auditory relay center and it may serve as a center in which pain and tactile impulses are interrelated with those of the auditory center (Talmage, 1977). The inferior colliculus is generally considered to be the second obligatory synapse in the auditory pathway (Strominger et al, 1977) .

Fibers project from the inferior colliculus to the ipsilateral medial geniculate nucleus in the thalamus via the brachium of the inferior colliculus. A minor projection also goes through the commissure of the inferior colliculus to the contralateral medial geniculate nucleus (Pfingest and Larson,

1982). In addition the medial geniculate body receives fibers from the lateral lemniscus, superior olivary nucleus and cochlear nuclei. The synapse between third and fourth-order neurons in the medial geniculate body is considered to be the rostral termination of the brain stem (Carhart, 1969). At the medial geniculate body final sorting and recoding of information occurs before being projected to the temporal lobe (Lynn and Gilroy, 1976).

After this last subcortical relay station for auditory impulses, nerve fibers fan out as auditory radiation to ascend to the auditory cortex. The medial geniculate body is considered as the only access of auditory fibers to the auditory cortex (Keidel et al, 1983). The nerve fibers terminate in temporal lobe of the cortex which is located primarily on the superior medial and lateral surfaces of the superior temporal gyrus and thus, is buried for the most part within the Sylvian fissure (Imig et al, 1977). This area is called the primary auditory area or Heschl's gyrus or area 41 of Brodmann. Other areas of the cortex are stimulated by auditory signals as well as stimulated by other sensory signals. These are called the association areas and they occupy the floor of the Sylvian fissure behind the primary auditory area in the region known as the planum temporale. The auditory association cortex on the left side is known as Wernick's area (Keith, 1984). The auditory reception areas of the two temporal cortices are interconnected by nerve fibers that lie in the splenium of the corpus callosum.

Ascending auditory pathways may give off collaterals that terminate in other areas of central nervous system including some

collaterals that terminate in the cerebellum Keidel et al (1983) showed that these connections may be related functionally to localization of sound source. There are collaterals to the reticular formation where the connection of the reticular activating system with the auditory pathway occurs at the level of the brain stem. This system is implicated in control of the level of consciousness and arousal reaction (Keidel et al, 1983) and it receives information from all sensory systems. The reticular formation has also a discriminative function, inferring that this system aids the cortex in selecting signals which are of focal importance while inhibiting others (Magoun,1963). There are connecting fibers between the inferior colliculus and the visual system's superior colliculus, thereby providing an intersensory neural connection (Beasley and Rintelmann,1979).

The efferent (descending) auditory system begins as projections from the auditory cortex that descend first in auditory radiations to terminate on both sides of the brain in the olivocochlear bundle (bundle of Rasmussen). This bundle conveys messages from the central nervous system outward to the ipsilateral and contralateral cochlea in order to exhibit a feedback regulatory control all along both organs of corti (Rasmussen, 1965).

Organization Of The Central Auditory Nervous System Function:

The central auditory system function is complex and the central auditory pathways do not perform only analysis of isolated parameters of frequency, amplitude and time as is the case within the peripheral auditory system (Zwentow et al, 1975). Other functions of the central auditory nervous system include identification of succession and distribution of the perceived information (Zwentow et al, 1975). In addition, auditory stimuli are not simply transmitted by passive conduction along the central neural pathways as there is continuous analysis at all levels of the auditory system from cochlea to cortex (Keith, 1982). First, analysis of frequency of the incoming signal is provided by neurons that are individually tuned to provide a frequency selectivity response (Zwentow et al, 1975). These neurons are characterized by being tuned to respond maximally to a specific frequency but still they can respond to other frequencies at higher intensities. Further analysis of sound stimulus occurs in neurons sensitive to variations in interaural phase relation or neurons activated by stimuli to one ear and inhibited by contralateral stimuli (Keith, 1982).

In addition to analysis, encoding and recoding occur at all levels of the auditory pathways. This first starts at the cochlear nucleus then proceeds to the superior olivary complex. At the superior olivary complex two distinct auditory functions appear (Carhart, 1969). One is unilateral where the stimulus, as recoded at the ipsilateral cochlear nucleus, is transmitted across the midline to the contralateral superior olive and

remains a contralateralized unilateral signal as it ascends to the higher auditory pathways. The second function is binaural where stimuli at the cochlear nuclei project to both ipsilateral and contralateral superior olivary nuclei. Thus, bilateral stimuli from both ears are integrated for the first time in the central auditory pathways at this level. This binaural function serves as the basis of summation and resynthesis of information arriving at the two ears as well as appreciation of direction and localization of sound in space (Lynn and Gilroy, 1976). At higher levels decussation occurs at the lateral lemniscus and commissural fibers pass between the two inferior colliculi with further contribution to the binaural auditory functions (Talmage, 1977). The bilateral representation continues further till the cortical level where each hemisphere receives input from both ears (Philips and Gates, 1982). However, the contralateral ear receives a stronger representation in the central auditory pathways than the ipsilateral ear (Carhart, 1969). This dominance of the contralateral pathways is attributed to the greater number of fibers and the faster transmission speed in the crossed pathways than in the ipsilateral pathways (Rosenzweig, 1951).

Another criterion which helps analysis of incoming auditory stimulus is the tonotopic organization of the central auditory pathways. This organization means that the cochlea is represented tonotopically at all levels along the auditory pathways. It starts first at the cochlear nuclei where different characteristic frequencies are arranged in a systematic manner for the separation of high tone responsive fibers, middle tone

responsive fibers and low tone responsive fibers (Snow, 1966). This orderly arrangement is maintained throughout the central auditory system up to the temporal cortex as it carries on its surface a map of the cochlea (Woolsey and Walzl, 1942; Tunturi, 1944).

Further processing of auditory information occurs in both subcortical and cortical levels where there is an incredible redundancy of the auditory pathways with multiple representations of the cochlea at all levels of the central system (Durrant and Lovrinic, 1977). This redundancy is attributed to anatomical construction of the central auditory nervous system with neuron order variability in the various nuclei of the system. Thus, alternative pathways are provided and they can allow comparison of the incoming signals against themselves or autocorrelation (Durrant and Lovrinic, 1977). The variability of neuron ordering also creates time disparities between signals arriving at the same level with redundancy of auditory input (Durrant and Lovrinic, 1977).

Further processing of auditory information received from both ears occurs at the cortical level with final analysis and interpretation of sound and association of sound with meaning occurring at this level (Durrant and Lovrinic, 1977).

The presence of two temporal lobes interconnected by neurons contributes to further redundancy in the organization of central auditory function (Durrant and Lovrinic, 1977). The two hemispheres do not subserve exactly the same function, as the left one is concerned mainly with language function including

speech perception and production and the right one is concerned with processing of music and other non verbal sounds (Kimura, 1964; Roeser and Daly, 1974). In addition, Kimura (1967) suggested that the right hemisphere processes non speech, vocal tract gestures necessary for humming, laughing, crying, etc that is, the right hemisphere is dominant for non speech sound produced by the voice. This was latter described by Moscovitch (1981) as the receptive language capacity of the right hemisphere for intonation, emotional tone, context, inference and connotation. These aspects represent the pragmatic part or the discourse function of the language. Moscovitch (1981) concluded that the primary function of the right hemisphere in non linguistic but any impairment of the right hemisphere might affect both verbal communication and memory functions.

Final processing of auditory information received in each hemisphere occurs by passage of this information between the two hemispheres across the transverse commissural callosal pathways (Sparks and Geschwind, 1968). Speech that is received, stored and sorted in the right hemisphere crosses to the appropriate association areas of the left hemisphere while non verbal stimuli are transmitted from the left to right hemisphere (Roeser and Daly, 1974). Finally, language stimuli induce neural activity in various association areas of the left hemisphere which lead to appropriate motor and intellectual responses (Lynn and Gilroy, 1976).