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Aims and Scope

JHLS publishes papers in both clinical and basic research related to hearing, balance, speech – language and swallowing. Articles accepted will be research articles, case studies, tutorials, perspective articles, policy and practice briefs and resource reviews. The articles selected will be peer reviewed. All articles are protected by copyright. Although care is taken in selection of articles, no legal responsibility for errors of omission will be accepted by either the author, editors, or publisher. No warranty is made for the content in the journal.

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gopeekrishnan.jhls@speechear.org

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ssmeera.jhls@speechear.org

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(Speech and Hearing)
Magpie Speech Therapy
JPNagar 7th Phase
Bengaluru
namratapai.jhls@speechear.org

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Introduction should lead to the need of the study and aims. Methods section must include study design, details of participants, materials used, rationale, procedure, and statistical analysis. Titles for figures and text must be clear and self-explanatory, providing information as a stand-alone structure. Stand-alone, high-quality figures and tables should be included in results section. Discussion section should provide understanding of results with support from literature. The manuscript should end with conclusion that brings out implication of the study.

All manuscripts should include acknowledgements, conflict of interest statement, ethical approval statement, participant consent statement, and funding statement at the end of the article.

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Ethical approval of the study and informed consent should be mentioned at the time of submission. Figures that include identifiable information about participants need to have an informed consent that is provided by the author.

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Articles are peer reviewed. Authors are encouraged to suggest reviewers, though the final decision is made by the editorial board.

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Fond Memories: Dr. James Jerger

The field of Audiology, recently bid adieu to Prof. James Jerger. I would be one of thousands who read his name a multitude of times all throughout their student days and careers, and cited his prolific research. During my Fulbright Junior Research Fellowship at the Callier Centre, Dallas, in 2004, my mentor Dr. Emily Tobey kindly arranged for me to audit a course taught by Dr. Jerger.

When I met him, I was literally star struck, taken in by his humble demeanor, soft voice and a sparkly smile that lit up his eyes. The course consisted of every student being given topics to present in class. I requested if I too could make a presentation although I was simply auditing the course. He promptly took me to his office and gave me two volumes of a very precious book from his prized collection- "Aphasia and Kindred Disorders of Speech", written by Sir Henry Head, a pioneer of Neurology who extensively studied the effects of brain injury through World War I times. The book was obviously much used, with yellowed pages, penciled notes, and bookmarks. Dr. Jerger told me to read both volumes and make a presentation on "Disorders of Perception". The presentation day was memorable- his satisfaction with the content I had chosen from the books; his explanations, feedback, and advise; his praise for my home-baked "pineapple upside down cake", and his smile when I returned his books with deep gratitude.

There was so much to emulate from him besides Audiology. He was 76 then, and still doing the same level of cutting-edge research as he did in his prime, also putting in the same number of work hours as people young enough to be his grandchildren. He joked that his recent interest in auditory issues of older individuals was because he was getting on in age, but in fact he seemed to be getting younger by the day with increasingly innovative research ideas that embraced contemporary technology.

After returning to India, I continued to correspond with him over the next few years. He always answered my queries promptly. It is difficult to express how special it felt to have him remember me, take time out to respond, get down to my level, and explain his point of view patiently. It meant so much to be able to cite "Jerger, J., (personal communication)". He will always be remembered for all the ways in which he touched our lives. RIP Father of Clinical Audiology!

Anuradha R. Bantwal
Audiologist and Speech-Language Pathologist
Mumbai

Fond Memories: Dr. Charles I. Berlin

Dr. Charles I. Berlin, renowned researcher, teacher, clinician and auditory neuroscientist, was lost to us in August 2024. His research expanded the horizons of audiology. Dr. Berlin started his professional career in speech pathology and moved to Johns Hopkins for a post-doctoral fellowship to learn "Medical Audiology". His knowledge and skills in varied areas including math, meteorology and music (Dr. Berlin trained at Juilliard's School), fitted him to obtain knowledge from exposure to dissection, genetics and electrophysiology. His work at Johns Hopkins led to his appointment as head of the Communications Science laboratory in LSU for several decades. The lab was later named as the Kresge Lab.

Dr. Berlin was known for his multidisciplinary approach which was epitomized in the work at Kresge lab of which he was the director. The book series he edited on Hair cells and Hearing aids, Neurotransmission and Hearing Loss and Otoacoustic Emissions, broadened understanding of sensorineural hearing loss from genetics to clinical practice in hearing aids. Most of the content reflected the work done in Kresge Lab.

The first publication on auditory neuropathy in 1996 of which he was one of the authors exemplifies his multidisciplinary approach. Dr. Berlin's many publications on dichotic listening and contralateral suppression of OAEs in musicians made waves and were the basis of my understanding in those areas. Our teacher, Dr. Shailaja Nikam was lucky to have worked with him. From her, we had heard a lot of Dr. Berlin's knowledge, and clinical work as well as his warm family life and care for his children and students as well.

So it was great news that he would be visiting India for the ISHACON 2006 in Ahmedabad, with stops in Mumbai and even Bangalore for a seminar. It was during this visit that I met Dr. Berlin (and Mrs. Harriet Berlin). In addition, I had an opportunity to make a presentation on Cochlear Pathology through Dr. Shailaja Nikam, (I cannot thank her enough for that). We had heard so much about the legend that I was nervous, but she told me "You will feel so good to share the platform with Dr. Berlin." - and she was right. It was an overwhelming experience to meet this legend and deliver my presentation in his presence in NIMHANS. I was really humbled to hear his appreciation.

Throughout the day he put at ease all who met him and shared his knowledge unstintingly, including a CD on hearing with hearing loss. He appreciated the work done here, and shared practical approaches to carry out testing. Simple ways of testing auditory processing that he demonstrated made a big impact. For e.g., can taps be used to test temporal perception? He demonstrated and it was so easy. The process to find a solution on the basis of the concept of the disorder made a difference to the way I and many others perceived our work as clinicians. Although his stay in Bangalore was shortened due to his daughter's hospitalization, we learned from him much more than auditory neuroscience and we left with warmth in our hearts after meeting him and Mrs. Harriet Berlin. Thank you Dr. Berlin.

Madhuri Gore
Dr. S. R. Chandrasekhar Institute of Speech and Hearing
Bangalore

Speech, Language and Cognitive Sciences: Exploring the Path of its Confluence

Prema Rao
(Former) Professor of Language Pathology,
All India Institute of Speech and Hearing
Maanasagangothri, Mysuru 570006

Abstract

The act of communication is carried out with ease by individuals in the society. Speech and language are the two essential components of communication. While speech is the ability to express thoughts and feelings with the help of voice and vocal organs, a structured system of conventional symbols adapted for communication is language. However, speech does not exist in isolation. The underlying cognitive components that interact with language lead to communication. In this article, an attempt is made to explore the path of confluence of speech, language and cognitive sciences. A brief review of a few terminologies, theories and models adapted in the three disciplines is provided to substantiate the discussion. Implications are derived with regard to the impact of confluence on clinical practice in speech-language pathology.

Key words:

Speech, Language, Cognition, Models, Clinical practice, Clinical outcome.

Address for correspondence: Email-rao.prema@gmail.com

Speech and language are the two essential components of communication. Speech is the ability to express thoughts and feelings with the help of voice and vocal organs whereas language is a structured system of conventional symbols adapted for communication. The phenomenon of communication has perplexed many scientists. Over the years, scientists are exploring to understand how individuals speak using appropriate language codes in a given society. In the recent years, a paradigm shift in the interest of scientists to link speech and language to cognition is evident in the majority of research.

Cognition is the mental process, by which sensory information is transformed, condensed, elaborated, stored, and retrieved (Neisser, 1967). A wide range of interrelated mental functions define cognitive ability including but not limited to attention, memory, coding, retention, recall, decision making, reasoning, problem solving, planning and execution Communication, on the other hand, is an active and intentional exchange of thought and messages between speaker and listener, language shares an intimate relationship with cognitive functions. Cognitive ability is crucial to retrieve and organize the linguistic units, verify, produce, judge for errors (if any), incorporate corrections (if needed), and watch/wait for listener's reactions/responses during the communication process. The cognitive system is sub-served by many other components among which attention, memory, organization, reasoning, and judgment skills are weighted as significant to execute the complex process of communication. In this article, an attempt is made to explore the path of confluence of speech, language and cognition. In the following sections, description of speech-language pathology as a discipline followed by a brief review of a few terminologies, theories and models adapted in the discipline is provided to substantiate the discussion.

Speech-language pathology as a discipline

In the past decades, speech and language were construed simply as oral production (speech, Van Riper, 1947) of thoughts (language, Piaget, 1926) in the mind. While Piaget believed that thought comes before language, Vygotsky (1986) stated that language and thought develop independently in a child and that both merge around 2-3 years of age. Further, Vygotsky argued that language serves as a tool for the development of cognition. This period may be treated as the beginning of understanding the intricate relationship among speech, language, and cognition. A spate of research between 1965 and 1975 spurred scientists to distinguish speech from language leading to the emergence of the discipline of speech-language pathology to serve persons with speech and language disorders.

Speech-language pathology is not only a synthesis of two fields of study but an amalgamation of many fields and their branches such as Audiology, medicine, special education, psychology, linguistics, acoustics, neurology, electronics and technology besides cognitive and neurocognitive science[1] to name a few. Cognitive and neurocognitive sciences, the two most closely related fields have contributed to the growth of the speech-language pathology as a discipline. Speech-language pathologists in turn, have gained an advantage to investigate in depth speech-language and communication disorders. Brain mapping of speech-language disorders and generating brain signatures (Boux et al., 2021) are the offshoot of coordinated research from these disciplines. The era of confluence of speech, language and cognition also made an imprint for a movement towards clinician-friendly terminologies and empirical procedures for clinical practice.

The following section gives an overview of the transitions in terminologies, theories and models that help to trace the path of confluence.

An overview of transitions

Speech-language pathology has witnessed substantial changes in its perspectives towards terminologies, theories, models, diagnostic and intervention methods. Research studies exploring the intricate relationship of speech and language functions with mental processes and neural circuits in the brain offer new directions to our understanding of speech-language mechanisms.

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[1] Neurocognitive science is the scientific field to study the biological processes that underlie cognition, with a specific focus on the neural connections in the brain involved in mental processes.

a) Terminologies

Significant changes in terminologies can be traced since 100 BCE to 200 CE as in Charaka Samhita and 1000 BCE to 600 BCE as in Sushmita Samhita, the period when speech function was documented in Sanskrit literature (Savithri, 1987). In the early decades of the 20th century, speech disorders were simply categorized as rhythm, articulation, phonation, and symbolisation (Van Riper,1947). With the description of characteristics of disorders, for example, defective articulation, the term articulatory apraxia of speech (Morley & Fox, 1965) was proposed. Around 1980's with the advancement in understanding the process of speech production, thrust was given to the interaction between motor skills and cognitive skills. While impairment in motor skills was termed as phonetic disorder, impairment in cognitive skills was termed as phonological disorder. Further, series of studies by Bishop et al., (2014, 2016, 2017) suggested overlap of language component on speech that was termed as speech sound disorder (SSD-phonology type).

Transitions in terminologies are also evident in both child and adult language disorders. Theoretical perspective of professionals seems to have influenced descriptions of language difficulties. Bernard de Gordon (1305) in the medical book on Lilium Medicine described language disorders as expression of a concept with difficulty. One of the earliest references to child language difficulties was by Gall (1835), a physician. He described children with specific problems in language in the absence of other conditions. In the subsequent years, Vaisse (1866) coined the term congenital aphasia for poor expressive language output in children. The term suggests that expressive difficulties are not always confined to production but are rooted to neurological deficits such as those seen in adults. Differential deficits between expressive and receptive skills were also observed indicating language subgroups (Liebmann, 1898 cited by Heim &.Benasich in 2015). A few other terminologies such as congenital word deafness (McCall, 1911), delayed speech development (Froschels, 1918), congenital auditory imperception (Worster-Drought *et al.* 1929), congenital verbal auditory agnosia (Karlin 1954) are also cited in child language literature. Leonard (2020) presents a list of 36 terms used from 1822 to 2009 to describe developmental language disorders. Similar transitions in terminologies for adult language disorders are also evident right from 'Tan-Tan' disorder (Joynt, 1861) through cognitive-linguistic disorders (Lakoff, 1990; Langacker, 1987; Talmy, 2000) to cognitive-communicative disorders (Christman, et al., 2004) encompassing even age-related and degenerative conditions. The transitions in terminolgies have set the stage to explore the interaction among mental processess, brain and language i.e., the relationship among speech, language, and cognition.

b) Theories and Models

The major impact of transitions in terminologies is on theories and models of speech and language. A theory is a set of concepts that explains a phenomenon, while a model offers a conceptual representation of ideas, events or processes derived from the theoretical information. Theories are formulated based on research data while models can be manipulated in a controlled manner to test theories. There are many theories (organic & functional; acquired & learnt; innate & behavioral; cognitive, environmental) and models (medical, behavioural, neurodevelopmental, neurocognitive) to describe speech and language functions. Over the past two decades, the statistical learning theory has transcended across majority of the earlier theories. The statistical learning theory[2] requires several cognitive processes, one of which is the ability to encode the patterns in the input that reflect new language forms in to memory (Thiessen, 2017). According to this theory, infants learn language by pattern recognition rather than through innate biological mechanisms. Identifying and extracting patterns from speech that is continuous and rapid is an implicit process that happens without direct instruction. For example, a child learns to comprehend the continuous spoken utterance of the phrase /birdiesate/ (as 'birdies ate') or /prettybaby/ (as 'pretty baby') through implicit process employing statistical learning principles. Plante & Gomez (2018) are of the opinion that the ability to segment continuous speech on the basis of syllable-level transitional probabilities denotes statistical learning.

Consequent to the support for the statistical learning theory from the scientific community, speech-language acquisition was described on the basis of the declarative procedural (DP) model emphasizing co-optation of biological substrates. On the basis of DP model, Ullman and Pierpont (2005) proposed procedural deficit hypothesis (PDH) to account for the language disorders in children. The DP model and PDH are detailed in later sections.

According to the Standard Model (Levelt, 1992), speech production is envisaged as three stages of conceptualization, formulation, and articulation that extends the act of speech to embrace cognitive components. Whereas, the Motor Theory of speech perception (Liberman & Mattingly, 1985) suggests that speech perception is a process of matching the motor movements to the acoustic patterns (speech sounds). This theory links speech to cognitive component of matching and decision making. Recent study by Noiray et al., (2019) on phonemic awareness and coarticulation reported that the process of developing spoken language fluency involves dynamical interactions between cognitive and speech motor domains.

The above theories of speech production and perception invariably implicate the intimate relationship between speech-language and cognition. A few widely accepted theories of language acquisition also strongly relate language to mental processes that are governed by the brain. For example, Chomsky (1976) and other proponents of Biological Maturation Theory and Linguistic theory, view the process of talking as equivalent to walking with specific sequence of development. Brain maturation studies have revealed that the structures and systems of brain that support other motor behaviors (for example, eating, chewing, etc.) are recruited for speaking that develops in sequential and organized pattern. Despite the 'nature-nurture' phenomenon in the maturation phase, connection between mental processes in the brain and speech-language behaviour has been strongly emphasized.

As a corollary to the above, the information processing theory focuses on the role of internal information processing mechanisms for language acquisition. A single path serial model of cognitive processing (sensation-perception-cognition-memory) is drawn to explain language acquisition.

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[2] Statistical learning theory states that language is learned by analyzing the statistical patterns in natural language. Further, it states that learners use the statistical properties of language to understand its structure, including words, sound patterns and the basics of grammar.

Computer modeling of language acquisition such as connectionist model and parallel distributed processing (PDP) model further state that incoming information is processed either through bottom-up, top-down, and/or interactive processes, a‘nd that attention and working memory help to distribute information to several nodes simultaneously. All these processes are rooted in the cognitive system of a child learning to speak. Therefore, the cognitive scientists who study how the nervous system represents, processes, and transforms information are also interested in the study of speech and language mechanisms.

One of the recent models, the declarative-procedural model also called as DP model (Ullman, 2004) offers empirical evidences for the cognitive basis as described in the previous models The first principle of the DP model states that new biological functions commonly recruit pre-existing biological mechanisms that are further evolutionarily or developmentally specialized. That is, the biological mechanisms often co-opt for new purposes. In the earlier section, it was noted that Sapir (1921) viewed speech as an overlaid function. Sapir’s statement that the vocal organs meant for other biological functions however, cannot be undermined. Yet, the process of speech being not as simple as indicated, the perspective of co-optation of biological substrates as described by Ullman in DP Model may be considered to substantiate Sapir’s view.

The essence of cognitive theory is that development across domains may be explained by postulating a general set of cognitive structures and processes among which language per se, does not hold any special position. Accordingly, the sequence and rate of cognitive development influence the sequence and rate of language development. The second principle of DP model suggests that most of language must be learned for which children learn to recruit the general set of cognitive structures and processes. The DP model is in support of the proposition made by Piaget that the cognitive processes of adaptation, assimilation and accommodation facilitate learning.

With reference to the range of domains and functions subserved by the structures of the brain, declarative memory and procedural memory are deemed to be the two most important learning and memory systems (Ullman, 2008). The declarative memory system which is fast and explicit refers to the entire system involved in learning, representation and use of knowledge about facts (semantic knowledge) and events (episodic knowledge) (Eichenbaum, 2000). It is important for rapid learning of arbitrarily-related information. On the other hand, the procedural memory system which is slow and implicit (Eichenbaum & Cohen, 2001) which subserves new learning besides taking control of the earlier established sensori-motor and cognitive skills. For example, riding a bicycle or swimming is carried out with the help of implicit memory system that is not a conscious process and therefore, is procedural in nature.

The third principle of the DP model posits that the two memory systems are highly likely to play important roles in language learning, knowledge, and use. The brain structures that subserve declarative memory play analogous roles in lexical memory and those underlying procedural memory subserve the mental grammar. Hence, the aspects of grammar are learnt with the help of procedural memory system while the lexical memory depends largely on declarative memory system. The declarative and procedural memory systems interact in a number of ways to form a dynamically interacting network which yields both cooperative and competitive learning and processing, such that memory function may be optimized (Poldrack & Packard, 2003). The DP model is also largely compatible with many linguistic and psycholinguistic models of language and therefore, is considered as a neurocognitive model.

c) *Impact of confluence of disciplines on clinical practice*

A brief summary of transitions in terminologies, theories and models gives an overview of how the three fields-speech, language and cognitive sciences converge by sharing principles, ideas, theories and models. Owing to the convergence of these sciences, significant benefits accrued for clinical research and practice in speech-language pathology. For example, interface of disciplines has laid the path to new thinking for either formulation of theory, diagnostic evaluation and/or intervention strategies. As mentioned earlier, Sapir's proposition of speech as an overlaid function (Sapir, 1921) may be theorized with the rationale of co-optation of neural substrates (Ullman, 2005). On a similar note, the underlying source for the symptom of word finding difficulties (e.g., storage and/or access, Warrington and Shallice, 1984) in persons with language disorder is derived from cognitive-linguistic research. Word finding difficulties are bracketed either under storage deficits (damage to the semantic representation) or access deficits (intact semantic representation but impaired access to the lexicons). Knowledge gained from cognitive-linguistic studies has guided to design appropriate strategies for clinical intervention, one of the strategies being semantic feature analysis (SFA, Boyle & Coelho, 1995).

Similarly, fluency disorder that is considered as a speech disorder for long is viewed as a condition due to neural circuit deficits causing cognitive-linguistic impairments. Functional MRI studies on fluent and dysfluent speakers at the Max Planck Institute for Human Cognitive and Brain Sciences (see Neef et al., 2018 for more details) offers interesting findings. While right frontal region is primarily involved in speech production of fluent speakers (Guenther, 2016), adults who stutter are found to have hyperactive Frontal Asland Tract (FAT) in the right Inferior Frontal Gyrus (IFG) that inhibits planning and execution of speech movements. Inhibition due to hyperactive network also causes delay in lexical retrieval causing longer reaction time for execution thus affecting timing of speech movements. Rationale for age-old technique, prolongation of speech to improve fluency therefore, may be derived from the above findings. Prolonged utterances may counteract the effect of hyperactive network in persons with fluency disorders.

It is well known that in the traditional approach, strategy to teach vocabulary is by designing tasks for matching, discrimination, identification, repetition and naming. Contemporary strategies devised based on the recent models are deemed to activate the neural substrates and the functional domains in the brain structure thus leading to rapid and long-term clinical outcome. The connectionist's models (McClelland & Elma, 1986) such as Trace, Cohort, Spreading activation and Neighbourhood activation models activate nodes in the neural network for learning either in parallel, distributed or interactive ways. For example, for words such as /'captain', capital', 'caption', 'capsule', when a part of the word (say, /cap/) is given, the individual learns to recognize/say/read the subsequent part of the word. Similarly, for words /'best', 'nest', 'rest'/ etc.), initial part of the word is processed with information from the word final /-st/ due to the activation of the nodes as detailed in the connectionists model. As mentioned earlier, Semantic Feature Analysis is another widely used technique to improve naming abilities by increasing the level of activation of nodes within a semantic network to enable an individual to have easier lexical retrieval. Spaced repetition and retrieval practice (Darian, 1979), the redundancy strategies used in language teaching helps to reconstruct as well as strengthen information processing pathways. These may be accounted as compensatory strategies to enhance declarative and procedural memory circuits.

Scientists over the past 50 years are investigating to discover powerful mechanisms for learning novel language input. Statistical learning research has produced evidences for learning with little perceived effort to acquire the complexities of language. In this direction, phonologic/syntactic (Gleitman, 1990), semantic (Pinker, 1984) and prosodic bootstrapping techniques for language intervention may be treated as techniques based on the principles of implicit process of statistical pattern learning. Plante & Gomez (2018) state that clinical outcome is much faster with implicit statistical learning strategies where learners extract regularities without conscious intent or knowledge of patterns. This contrasts with explicit teaching that capitalizes on the learner's own cognitive resources to trace and track the input information structure. Further, there is evidence that statistical patterns, once learned, are retained over time (Frank, Tenenbaum, & Gibson, 2013). Clinicians may therefore, exploit the cognitive resources that support rapid learning by intentionally avoiding explicit teaching in favor of implicit learning.

Summary and Implications

An attempt is made in this article to trace the path of confluence of speech, language and cognitive sciences. In order to substantiate the interface of the three sciences as well as the disciplines, support is drawn from the transitions in terminologies, theories and models. The confluence of the three fields has provided stronger empiricism for research and clinical practice, specific treatment procedures with reliable treatment outcome measures (TOM), value-based framework for the services of speech-language pathologists that further add-on to advocacy and marketing. The continuum of speech, language, and cognition and their dynamic interactions are highly intriguing. Therefore, clinicians and researchers in the field need to acquire knowledge and skills in these disciplines to impart optimum services to persons with communication disorders.

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EEffect of Duration of Monaural Amplification on the Speech Identification Scores of the Non-aided Ear

Asha Yathiraj[#] **and Amruthavarshini B.**[##]
[#]Professor of Audiology
JSS Institute of Speech and Hearing, Mysuru
[##]Clinical Audiologist, Amplifon, Mysuru

Abstract

Aims: Prolonged use of monaural amplification has been observed to result in auditory deprivation in the non-aided ear, with no such decrement in the aided ear. The present study aimed to find how early after the use of monaural amplification the deterioration could start. The study also aimed to determine whether the quantum of deprivation in the non-aided ear varies as a function of the duration of use of monaural amplification.

Methods: Adults with bilateral acquired moderate to moderately-severe symmetrical sensorineural hearing loss were studied. The 39 adults aged 18 to 50 years had used their prescribed hearing aid in one ear for durations ranging from 1 to 9 years and did not alternate the device between the two ears. Their current speech identification scores were determined for each ear separately. Their speech identification scores, prior to their use of hearing aids, were obtained from their case files maintained at the clinical facility.

Results: Significant improvement in speech identification scores was seen in the ear in which the hearing aid was used. However, a significant decrease in scores was observed in their non-aided ear. No significant correlation was seen between the number of years of hearing aid use and the speech identification scores of the non-aided ear. Also, there was no significant difference in the unaided ear scores between those who used the device for 1 year compared to those who used it for more than 1 year.

Conclusions: Lack of amplification can lead to auditory deprivation in the non-aided ear of individuals with symmetrical hearing loss who use monaural amplification. This can occur as early as 1 year after the use of the device. Thus, it is recommended that monaural hearing aid users should not use their hearing aids consistently in only one ear. It is suggested that they should alternate their monaural hearing aid between the two ears. However, it is more ideal that they use binaural amplification.

Key Words: Auditory Deprivation, Hearing aid users, Speech Perception.

Address for Correspondence: Asha Yathiraj **asha_yathiraj@rediffmail.com**

Introduction

Binaural amplification in individuals with symmetrical sensorineural hearing loss has been reported to bring about significant benefit in speech identification (Chung & Stephens, 1986). In line with the earlier studies, Köbler et al. (2001) reported that participants with bilateral symmetrical mild to moderately-severe sensorineural hearing loss had a high preference for binaural amplification over monaural fitting. However, one-third of their subjects preferred only one hearing aid, which was attributed to ear asymmetry. Noble and Gatehouse (2006) noted a significant difference between the responses of unilateral and bilateral hearing aid users on the Speech, Spatial, and Qualities of Hearing scale. Their participants reported more benefits with two devices for directional hearing and movement discrimination than with a single device. However, unilateral amplification was noted to assist in one-to-one conversations. Apart from the advantages in challenging situations, Kim et al. (2014) observed that their binaural amplification users had significantly greater acceptance of noise compared to the monaural amplification users. This was observed on a task that assessed acceptable noise levels.

Although binaural amplification has several advantages, not everyone who requires them chooses to wear two hearing aids. In monaural hearing aid users, auditory deprivation in the non-aided ear of monaural amplification users has been shown in studies. Silverman and Emmer (1993) observed that word scores dropped in the non-aided ear of the six monaural hearing aid users they studied. However, they did not mention the duration of the deprivation. Additionally, they reported of a recovery in two out of the six subjects after the use of binaural amplification, but did not mention of the quantum of recovery.

The effect of the duration of use of monaural amplification on the reduction of speech identification scores in the non-aided ear has also been studied by Gelfand et al. (1987). They observed that auditory deprivation occurred in the non-aided ear of monaural hearing aid users. This reduction of word scores was seen in the non-aided ear after four years or more of use of monaural amplification. Hurley (1993) also noted that their nine subjects fitted with monaural amplification had a steady decline in speech recognition scores in the non-aided ear. This reduction in scores was observed as early as one year post-fitting or as late as 5 years after the initial monaural fitting. Likewise, Silverman and Silman (1990) reported of a decline in word identification scores in the non-aided ear after 22 months of use of monaural amplification in two individuals. With the use of binaural amplification for approximately 2 years, this deprivation recovered partly in one and completely in the other.

Similarly, it was noted by Gelfand (1995) that their six subjects with bilateral symmetrical sensorineural hearing loss had significant auditory deprivation. However, the poorer performance in the non-aided ear was observed within 2 years of use of monaural amplification, with it occurring as early as 6 months in one participant. The decrease in speech recognition scores of the non-aided ear ranged from 14% to 48%. Two of the subjects exhibited a delayed onset of auditory deprivation that commenced after 6 years in one and 11 years in the other. While complete recovery was seen after just 10 months of consecutive binaural amplification in two subjects, two had incomplete recovery even after several years of binaural amplification. The other two participants who had delayed onset of deprivation failed to recover even after years of binaural fitting.

From the review of the literature, it can be observed that the non-aided ear of monaural hearing aid users tends to exhibit auditory deprivation. The deterioration was found to commence as early as 6 months and was seen to be present in those using the device for up to 15 years. However, the studies vary considerably regarding how early the deterioration could start. Also, it has not been studied whether the quantum of deprivation in the non-aided ear varies as a function of the duration of use of monaural amplification.

Further, several of the earlier studies on the deterioration in speech identification in the non-aided ear of monaural hearing aid users have been conducted on adults aged 50 and above (Byrne et al., 1992; Gelfand, 1995; Gelfand et al., 1987; Schreurs & Olsen, 1985; Silman et al., 1984). It is known that with advance in age, the probability of having auditory processing problems increases (Kumar & Sangamantha, 2011; Sanchez et al., 2008; Vaidyanath & Yathiraj, 2015). Thus, the findings of studies reporting deterioration in the non-aided ear may be confounded with age-related problems. This may mitigate the actual effect of auditory deprivation. Hence, to understand the true effect of auditory deprivation in the non-aided ear, younger adults with bilateral symmetrical hearing loss need to be studied. Additionally, many of the studies reported in the literature have small sample sizes, making it difficult to generalize their conclusions. Hence, studying a larger group of individuals using monaural amplification is required. Thus, the present study aimed to examine the effect of the number of years of monaural hearing aid use on the speech identification scores of the non-aided ear. The study also aimed to compare the speech identification scores before and after the use of monaural amplification, separately in the aided and the unaided ear as well as between the two ears before and after monaural amplification.

Methods

The study was carried out using a pre-post design. Using a purposive sampling technique, speech identification scores of adults using monaural amplification were evaluated before and after the use of monaural amplification, in the aided ear as well as the non-aided ear. Information regarding the number of years of monaural hearing aid use was also obtained. The study was carried out as per the ethical guidelines of the institute (All India Institute of Speech and Hearing, 2009).

Participants

Thirty-nine adults, aged 18 to 50 years (mean age = 35.4 years) and diagnosed to have bilateral mild to moderately severe acquired symmetrical sensorineural hearing loss (pure-tone averages = 30 dB HL to 70 dB HL) were studied. Among them 26 were males and 13 were females. It was ensured that they had bilateral stable hearing loss that had not changed over a period of four to five years. This was ascertained from the audiological findings maintained in their case files. The participants were required to have used digital behind-the-ear hearing aids prescribed by qualified audiologists for durations greater than one year. The participants selected used their devices for periods ranging from 1 to 9 years. Only those who did not alternate their device between their two ears were selected. None of them had any history of middle ear problems or any speech and language problems. All the participants had at least a secondary school education with the language of instruction being either Indian-English or Kannada.

All the audiological tests were carried out in an acoustically treated suite that met the specifications of ANSI S3.1-1999 (R2013). The testing suites had optimum temperature and lighting and were free of any type of distractions.

Procedure

Informed consent was obtained from the participants, adhering to the guidelines of the institute. Participants who met the inclusion criteria were subjected to a face-to-face interview to obtain their case history, especially regarding their hearing aid usage. This included information regarding any variations in hearing abilities after the onset of hearing loss; the type of hearing aid used; duration of hearing aid use; number of times they changed the devices utilised by them; and whether they used their hearing aid constantly in one ear or alternated between their two ears. From the case files of the participants, maintained in the institute's official records, the following were noted regarding the evaluations done at the time of hearing aid prescription: Information pertaining to their hearing thresholds; immittance findings; and the unaided speech identification scores for each ear, measured under headphones.

The participants who met the inclusion criteria were subjected to basic audiological testing. The pure-tone air conduction and bone conduction thresholds were measured using the modified Hughson and Westlake procedure (Carhart & Jerger, 1959). This was done using a calibrated dual-channel audiometer (Inventis Piano), with TDH-39 headphones, B-71 bone vibrator. The air conduction and bone conduction thresholds were evaluated at octave frequencies between 250 Hz to 8 kHz and 250 Hz to 4 kHz, respectively. Additionally, their middle ear function was tested using a calibrated immittance meter (GSI tympstar). Tympanograms were measured using a standard 256 Hz probe-tone. The ipsilateral and contralateral acoustic reflexes were obtained at 500 Hz, 1 kHz, 2 kHz, and 4 kHz in both ears. The participants were subjected to further evaluation only if their pure-tone and immittance findings did not alter from the baseline evaluation carried out at the time of hearing aid prescription.

Speech recognition thresholds were measured using CID-22 spondaic words (Hirsh et al., 1952) or paired Kannada words developed in the Department of Audiology, All India Institute of Speech and Hearing. Speech identification was evaluated using phonemically balanced words developed by Yathiraj and Vijayalakshmi (2005), when testing Kannada speakers or by Yathiraj and Muthuselvi (2009), when testing Indian-English speakers. Speech recognition threshold and speech identification were measured for each ear independently. The participants were tested in Kannada or Indian-English depending on the language that they had been tested earlier. It was ensured that they had been evaluated on the same test earlier, based on the information available in the case files.

The stimuli were presented at 40 dB SL (Ref. SRT) or at a lower level, if restricted by their hearing level. The participants were instructed to listen to the stimuli carefully and to repeat the words heard by them. The scores from the previous evaluations were tabulated along with the speech identification scores of the present evaluation. The duration the participants had used their hearing aid constantly in one ear was also noted.

Analyses

The data obtained from the case files and from the evaluations carried out on the participants were statistically analysed using SPSS (Version 20) software. Shapiro Wilks test of normality indicated that the data were not normally distributed. Hence, non-parametric statistical tests were conducted.

Results

The scores prior to and after the use of monaural amplification were compared using a Wilcoxon signed-rank test. This was done separately for the scores in the aided ear and in the non-aided ear. Additionally, the correlation between the number of years of hearing aid use and the speech identification scores of the non-aided ear was also determined.

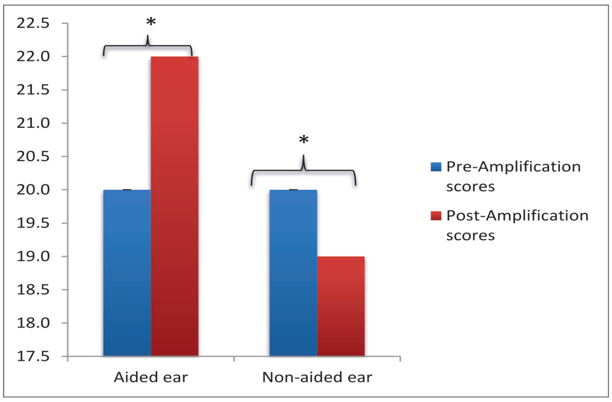
The mean and median speech identification scores were similar in the left and right ears, prior to the use of amplification. However, after the use of the hearing aid, the scores were better in the aided ear compared to the non-aided ears of all the participants (Table 1 & Figure 1).

Table 1: *Mean, Median, Standard deviation (SD) and 95% confidence interval (CI)) of the speech identification scores prior to and after monaural amplification in the aided and non-aided ears.*

Parameter	Aided ear scores		Non-aided ear scores	
	Pre amplification	Post amplification	Pre amplification	Post amplification
Mean	19.84	21.61	20.1	19.58
Median	20.00	22.00	20.00	19.00
SD	2.2	1.59	1.96	1.94
95% CI	19.12 - 20.56	21.09 - 22.13	19.49 - 20.76	18.95 - 20.21

Note : Maximum possible total word score = 25

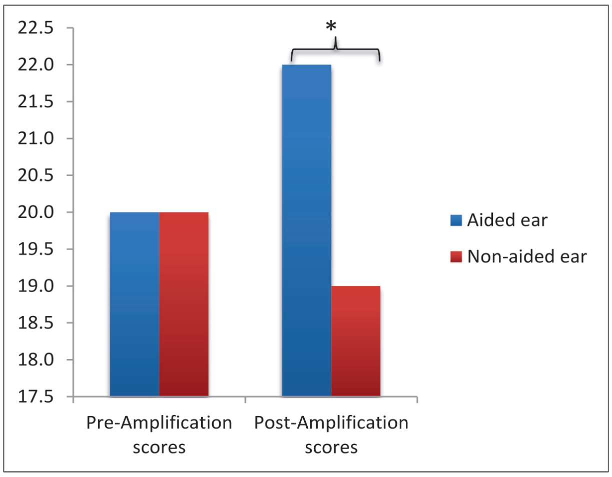
Comparison of the scores prior to and after the use of monaural amplification was done using a Wilcoxon signed-rank test (Figure 1). Significant improvement in speech identification scores was seen after the use of amplification in the ear in which the hearing aid was used [$Z = 4.75, p < 0.01$]. However, a significant decrease in scores was observed in their non-aided ear [$Z = 2.49, p < 0.05$].



Note. * = $p < 0.05$

Figure 1. Median speech identification scores prior to and after the use of monaural amplification in the aided and non-aided ears

Comparison of scores in the aided and the non-aided ear was also evaluated using a Wilcoxon signed-rank test. This was done for the scores obtained in the two ears before the use of amplification and the two ears after the use of amplification. As can be seen in Figure 2, before the use of amplification no significant difference was seen between the two ears [$Z = 1.32, p > 0.05$]. In contrast, following the use of amplification, the speech identification scores were significantly poorer in the non-aided ear compared to the aided ear [$Z = 4.63, p < 0.001$].



Note. * = $p < 0.05$

Figure 2. Median speech identification scores of the aided and non-aided ear prior to and after the use of monaural amplification

Effect of the number of years of hearing aid use and speech identification scores of the non-aided ear was determined by checking their correlation as well as the significance of difference. A Spearman's correlation, done between the number of years of hearing aid use and the speech identification scores of the non-aided ear, was not significant (r = 0.24, p > 0.05). Further, a Wilcoxon signed-rank test also indicated no significant difference in the unaided ear scores between those who used the device for 1 year compared to those who used it for more than 1 year [Z = 0.21, $p > 0.05$].

Discussion

The results indicated that monaural amplification resulted in a marked decline in speech identification scores in the non-aided ear. These findings are in consonance with the findings of Boothroyd (1993) and Hurley (1993), who also observed a significant decrement in speech identification scores in the non-aided ear. Thus, the use of monaural amplification, constantly in one ear, can result in auditory deprivation, resulting in poorer speech identification in the non-aided ear. This may be attributed to the modifications in experience-related reorganization within the central nervous system due to auditory deprivation. Studies have also provided electrophysiological evidence regarding the cortical reorganization due to changes in acoustic environments (Kraus & McGee, 1995; Menning et al., 2000).

Further, in the current study, the duration of use of a monaural hearing aid did not have a significant correlation with the speech identification scores obtained in the non-aided ear. However, on examination of the individual scores obtained by the participants in their non-aided ear, it was observed that a few participants who had used their monaural amplification for just two years had as much deterioration as those who had used the device for longer durations. Thus, just one year of not using amplification in an ear resulted in almost similar deterioration in speech identification as seen in those who had deprivation for longer durations. This finding are in consonance with the findings of Hurley (1993) who also found that the reduction in scores could commence as early as one year post fitting of monaural amplification.

Although the speech identification scores of the non-aided ear decreased significantly, not all individual showed a marked reduction in scores. Five of the 39 participants showed no change in speech identification scores in their non-aided ear. This indicates that the quantum of deterioration varies across participants. However, this variation in scores in the non-aided ear did not depend the number of years of use, as mentioned earlier. This finding was in line with that of Gelfand (1995) who reported that the commencement of deterioration varied across the participants. Thus, it can be construed the use of monaural amplification can result in no deterioration in the non-aided ear to marked deterioration, after one year of use.

The findings also indicate that although the participants studied were relatively young adults aged 18 to 50 years, auditory deprivation did occur. However, compared to studies mentioned in the literature (Gelfand, 1995; Köbler & Rosenhall, 2002; Silman et al., 1984), the quantum of reduction in speech identification scores in the non-aided ear of monaural hearing aid users of the present study was relatively less. It is highly likely that the findings of the studies reported in the literature were influenced by age-related deterioration, which was not present in the current study, as most of the participants (n = 30) were below the age of 40 years. Thus, the findings of the current study can be attributed purely to auditory deprivation and not due to the compounding effect of age-related changes.

To prevent a deterioration in speech perception due to the use of monaural amplification constantly in one ear, it is ideal that individuals with bilateral hearing loss use binaural amplification. However, for those who do not wish to use binaural amplification, either due to personal preferences or due to financial constraints, alternating the device between the two ears is recommended. Such alternating has been found to retard such deprivation.

Conclusions

The current study demonstrated that consequent to auditory deprivation, the non-aided ear of individuals using monaural hearing aids had a reduction of speech identification scores. The study also highlights that such deterioration can occur even in young adults after just one year of deprivation. This reduction in scores was seen in most of the participants, with the quantum of reduction varying across them. While it is ideal that those with bilateral hearing loss use binaural hearing aids, for those who prefer to use monaural amplification or cannot afford to purchase two devices it is recommended that they alternate the device between their two ears. This is recommended, provided the hearing aid settings are similar in the two ears. Further, the influence of the degree of hearing loss on auditory deprivation in monaural hearing aid users requires to be studied.

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Speech in Noise Training in Children with Auditory Processing Disorder

Dr. Prawin Kumar[1]; Ms. Nayana M[2]
[1]Associate Professor in Audiology;
Department of Audiology, AIISH, Mysore-570006
[2]Junior Research Fellow,
Department of Audiology, AIISH, Mysore-570006
prawinaudiology@gmail.com

Introduction

Speech perception in noise (SPIN) is the ability of the auditory cortex to identify the speech in presence of background noise by segregating the unwanted noise signal. Speech perception in noisy environments is a complex auditory process critical for effective communication, especially in dynamic situations like classrooms or playgrounds (Muthuselvi & Yathiraj, 2009; Crandell & Smaldino, 2000). Children with Central Auditory Processing Disorder (CAPD) frequently struggle to perceive speech in difficult listening environment. They often experience difficulty in filtering out irrelevant sounds and focusing on desired speech signals when these are presented concurrently (Cameron & Dillon, 2008). CAPD is not a deficit of hearing sensitivity but rather a disruption in how the brain interprets and processes auditory information, particularly in challenging acoustic settings. Auditory separation is essential for distinguishing desired speech from background noise, which is critical for effective communication in noisy settings. These deficits are linked to abnormal neural encoding of auditory information, particularly in areas responsible for temporal processing and binaural integration. Such limitations reduce their ability to process critical speech features, such as pitch, timing, and location, which are essential for distinguishing speech from noise. The deficit in speech-in-noise perception are also associated with reduced cognitive performance (Iliadou 2018). Consequently, the impact of these deficits is profound in educational settings, where listening is a basis of learning. Misinterpretation of spoken instructions and difficulty following conversations often leads to reduced academic achievement and weakened confidence in social interactions. Compounding these challenges are related cognitive factors, such as attention and working memory deficits, which further hinder their ability to adapt to noisy environments.

In India, 3.2% of children are at the risk for CAPD (Muthuselvi & Yathiraj, 2009). Efforts to address these issues have increasingly focused on targeted interventions, such as auditory training programs. Among these, computer-based auditory training has emerged as a promising approach, offering customizable and adaptive exercises designed to enhance speech-in-noise perception. These programs capitalize on the brain's plasticity, providing incremental challenges that help improve auditory and cognitive skills over time. Studies have shown that consistent training can lead to measurable improvements in speech perception, benefiting real-world communication and learning. Addressing speech-in-noise deficits in children with CAPD is crucial for enabling their success in noisy, language-rich environments. A comprehensive understanding of the underlying auditory and cognitive challenges, coupled with effective intervention strategies, can help mitigate the long-term impact of these difficulties, empowering children with CAPD to reach their full potential.

Auditory Training

Auditory training is an approach designed to enhance the brain's ability to process and interpret auditory stimuli. It helps improve skills such as speech recognition, sound localization, auditory memory, and attention, which are often impaired in individuals with APD. These trainings are often computer-based or delivered in structured sessions, gradually increasing in complexity. Auditory training aims to improve these abilities by providing targeted, repetitive practice. Programs often involve activities such as listening to speech in background noise, distinguishing between similar sounds, or following complex verbal instructions. The focus is on improving skills such as speech-in-noise perception, auditory memory, and attention. Research supports the effectiveness of auditory training in children with APD. Studies show improvements in various aspects of auditory processing, including speech recognition in noise, auditory attention, and memory (Chermak & Musiek, 2007; Moore et al., 2010). One key challenge in auditory training is the variability in how children respond to treatment. APD manifests differently in each child, and specific deficits may require tailored interventions. Moreover, there is no universally agreed-upon diagnostic criteria for APD, which can lead to inconsistencies in treatment approaches. Despite these challenges, auditory training remains a valuable tool in helping children with APD improve their auditory processing and communication skills. Few of the useful training strategies are mentioned in the following.

Speech-in-Noise Training

The neuroplastic ability of children's central auditory nervous system (CNS) enables them to reorganize and adapt to learning (Chermak & Musiek, 2002; Filippini et al., 2012). Targeted auditory separation (speech in noise) training has been shown to enhance auditory processing skills in children with CAPD (Jutras et al., 2019; Maggu & Yathiraj, 2011). Jutras et al., (2019) explored the effects of noise-based speech perception training on measures such as speech perception tests, electrophysiological responses, and real-life auditory behaviours. Their findings indicated improvements in speech perception test scores and certain electrophysiological indicators after training. Teachers reported positive changes in children's ability to understand rapid or muffled speech and to distinguish and identify speech sounds, as measured by auditory behaviour scale scores. This training not only improved speech perception in noisy conditions but also enhanced speech comprehension in other challenging listening environments. Speech perception training, also termed noise desensitization training (Katz & Burge, 1971), is designed to enhance tolerance for background noise, thereby improving speech perception in noisy settings.

However, effective training requires language-specific materials, which may limit its applicability in multilingual countries like India, where training content needs to be adapted for linguistic and cultural relevance. One such study in India was done by Maggu and Yathiraj (2011). They conducted noise desensitization training, using different types of noise such as speech noise, babble, and environmental sounds like fan noise to train children at various signal-to-noise ratios (SNRs) from +15 dB to 0 dB, depending on individual responses. They observed improvements in both open and closed-set word and sentence comprehension scores in noisy environments following training.

Schochat et al., (2018) used various auditory training methods such as, frequency training, intensity training, temporal training, dichotic intra aural intensity difference, localisation and speech perception. The training was provided to 22 children with CAPD and a comparison group of 30 children without CAPD was considered in the study. The outcome of the training was assessed using behavioural tests (Paediatric Speech Intelligibility (PSI), Speech in Noise SPIN, SSW, DDT and dichotic nonverbal test) and electrophysiological measure-middle latency response (MLR). The results showed a statistically significant differences in all the behavioural measures post training compared to the pre evaluation in CAPD group. The MLR results showed a significant pre and post differences only in terms of amplitude on CAPD group, whereas, there were no significant differences noted in the latencies. Comparisons of MLR results between the group with CAPD and the group without CAPD before and after training revealed a significant amplitude difference pre training, however this amplitude difference was not present post training. The evidence indicates that the auditory training program used by Schochat et al., (2018) can improve auditory processing ability on CAPD children.

Gohari et al (2023) conducted a review study on various training methods for improving speech perception in noise. In the review, the authors divided the training methods into bottom-up and top down procedures. The training involving bottom up approach included pitch training, fundamental frequency training, harmonics training, localization training, temporal and phonemic training. Whereas, the training using top-down approach involved memory-based training, music training and speech-in-noise training. They recommended selecting approach based on deficit underlying disorders.

Computer-Based Speech in Noise Training

In recent years, computer-based training programs have become increasingly popular among children, highlighting a growing interest across all age groups in interactive learning tools. The extensive variety of applications available for teaching phonetics, vocabulary, and academic subjects indicates this trend. Notably, computer-based auditory training programs have recently been implemented to help individuals with Central Auditory Processing Disorder (CAPD) and have shown positive effects on auditory processing skills (Gillam et al., 2008; Kumar et al., 2021a).

Several studies have shown improvements in speech in noise deficits through various computer-based training programs, including: (1) Earobics (Loo et al., 2010), which targets both auditory closure and phonological skills; (2) the Listening in Spatialized Noise Test (LiSN) (Cameron & Dillon, 2008), aimed at enhancing spatial processing and auditory closure; (3) Sound Auditory Training (Weihing et al., 2015), which focuses on temporal processing, binaural integration, and auditory closure; and (4) programs like Zoo Caper Skyscraper and Insane Earplane (Moses, 2016).

Studies by Hayes et al., (2003) and Warrier et al., (2004) used Earobics training module on children with learning problem. The outcome was measured using speech evoked cortical response with and without noise. Hayes et al., (2003) reported that the speech evoked cortical response followed the maturation pattern in children with learning problem on post training recording. Also, the waveform in noise condition displayed a robust P2N2 which indicates that there is a greater resistance in presence of noise. Warrier et al, (2004) reported among children with learning problem, a significantly increased N2 latency in presence of noise which fell into the normal range post training. Similarly Russo et al., (2005), in addition to speech evoked auditory brainstem response testing, included speech perception in noise in the outcome measure. The results of the study showed that the waveforms recorded in presence of noise were significantly different from the waveform recorded in quiet, however these difference reduced post training. Also, the benefit of the training was reflected in the improved SPIN score.

Cameron et al., (2012) assessed the efficiency of LiSN in children with spatial processing disorder. Training using LiSN was provided for 12weeks, 15 min each day. The results showed a significant amount of improvement in children's spatial processing skill which in turn improved the speech in noise perception.

Hassaan and Ibraheem (2016) developed a noise desensitization semi- formal program in Arabic language. The authors identified and trained 17 children with auditory figure-ground deficit. The outcome was measured using both behavioural tests (SPIN, DPT & CST) and electrophysiological (LLR). Results of the study showed a positive response on SPIN and DPT scores post noise desentization training program. Electrophysiological data revealed a significant difference in P1N1 component.

Afshari et al., (2022) investigated the effects of auditory spectro-temporal modulation (STM) training on children with auditory processing disorder (APD). There were two groups of 35 participants: the training group and the control group. The training group's speech perception in noisy environments and STM detection thresholds improved after ten days of STM activities. Significant post-training effects were shown by the results, with most gains remaining after a month, with the exception of word-in-noise retention under certain circumstances. The results demonstrate the potential of STM training as an intervention to improve children with APD's speech perception in noisy environments.

Donadon et al., (2019) evaluated the impact of auditory training on children with a history of central auditory processing disorder (CAPD) and otitis media. Thirty-four youngsters, ages 8 to 14, were split into two groups: one for visual training (n = 14) and another for auditory instruction (n = 20). The eight weekly sessions for the auditory training group focused on auditory skills such as figure-ground perception, temporal resolution and ordering, binaural integration. Dichotic Digits, Frequency Pattern, Gaps in Noise, and Synthetic Sentence Identification tests, demonstrated notable gains in auditory skills for the auditory training group. The specificity of auditory training effects was confirmed by the visual training group, which did not exhibit any notable alterations. The results emphasize the advantages of auditory training in improving auditory processing.

The study by Filippini et al. (2013) used behavioural measures and the auditory brainstem response to complex sounds (c-ABR) to examine the effectiveness of auditory training (AT) in children with specific language impairment (SLI) and auditory processing disorder (APD). APD, SLI with AT (SLIa), SLI without AT (SLIb), and usual development typical development (TD) comprised the four groups of thirty children, ages 7–13. The subjects participated in an 8-week AT program that focused on skills including dichotic speech perception and speech-in-noise. Prior to and following training, behavioural and electrophysiological evaluations were carried out. Improvements in behaviour tests, when compared to their pre-training performance, the APD and SLIa groups shown notable improvements in auditory skills such as figure-ground perception and temporal sequencing. Both the TD and SLIb groups showed no such gains. The APD and SLIa groups showed improvements in c-ABR measurements, especially in response to background noise. These alterations point to improved neural processing of speech sounds, which is explained by AT's influence on auditory systems at the brainstem level. The study highlighted the value of customized AT therapies for children with APD and SLI, emphasizing how it can enhance speech and auditory processing.

A computer-based noise desensitization training module was developed by Kumar and Singh (2020). The training module incorporated words-in-noise training using both monosyllabic and trisyllabic target words. These words were embedded in two types of noise: speech-shaped noise (SSN) and multi-talker babble (MTB). The target words were presented at varying signal-to-noise ratios (SNRs), ranging from +20 dB to -4 dB, to simulate real-life listening challenges. The training levels adaptively adjusted based on participant responses, gradually reducing the SNR to increase difficulty. This adaptive approach helped to systematically desensitize children to noise by training them to focus on speech under progressively challenging conditions. To maintain children's attention and motivation, the module included colourful visuals, animated graphics, and auditory feedback. For each correct response, children received visual and audio reinforcement, like congratulatory messages and animations. When children selected an incorrect answer, the screen displayed feedback highlighting the correct choice, allowing for targeted learning reinforcement.

Kumar et al., (2021a) studied the effectiveness of the module on 20 children diagnosed with SPIN deficits due to APD. These 20 children were evenly divided into an experimental group that received training and a control group that did not. Behavioural assessments (GDT, DCV, DPT, SPIN-IE, R-AMST) and electrophysiological tests, such as auditory long-latency responses in quiet and noise, measured the outcome of the module. Results indicated that the experimental group improved (better) SPIN scores after training in comparison to the baseline score. In addition, computer-based auditory training also showed a positive effect on GDT, DCV, and DPT tests except R-AMST. Electrophysiological data revealed reduced amplitude in auditory late latency responses post-training, suggesting neural adjustments aligning with auditory maturity. Further, a significant reduction in the amplitude of P1 peaks of ALLR in the presence of noise was observed among children with CAPD after training. This training module, tailored for Indian

English, shows promise as a resource-efficient intervention to enhance SPIN abilities in children with APD, with teachers reporting real-world benefits in classroom performance post-training. Along with the SPIN scores, improvements were also noticed in temporal processing measures, despite no training being imparted in these domains. This finding is well supported by the finding of Hoover et al (2015) who reported a strong correlation between SPIN perception and temporal processing. Along with the subjective and objective audiological measures, feedback was also obtained from the teachers one month after cessation of the CBAT, they reported improvement in the listening skills along with reduced strain and better attention to attend to the auditory-based stimuli in the presence of background noise. Studies have reported similar generalizations of the improvements in the speech in noise test scores in real-world situations after auditory desensitization training.

Kumar et al., (2021b) explored how speech-in-noise training affects both cognitive and auditory skills in children with Central Auditory Processing Disorder (CAPD). The study utilized cognitive assessments, including forward and backward digit span tests as well as ascending and descending digit span tasks, to evaluate changes post-training. The results revealed notable improvements in performance on the backward, ascending, and descending digit span tests. However, no significant correlation was found between cognitive and auditory outcomes, suggesting that while both types of skills are related, they function somewhat independently. These findings suggest that improvements in auditory processing abilities, specifically in speech-in-noise conditions, can positively influence cognitive measures such as working memory. The authors propose that this improvement may be due to the reallocation of cognitive resources—specifically working memory resources—following enhancements in auditory processing. As a result, children with CAPD might demonstrate better auditory memory skills due to more efficient use of these cognitive resources. The study supports the notion that auditory processing and cognitive functions, while interconnected, operate through distinct mechanisms, highlighting the potential benefits of interventions that target both auditory and cognitive domains in children with CAPD. This insight can help in designing more effective intervention strategies to address the complex nature of CAPD.

Conclusion

Speech-in-noise perception is a critical skill for children with CAPD, affecting their ability to understand speech in challenging environments such as classrooms. Deficits in this ability can lead to significant academic, social, and cognitive challenges. However, evidence suggests that auditory training, including noise desensitization training and computer-based programs, can improve speech-in-noise perception in children with CAPD. These interventions leverage the brain's neuroplasticity to enhance auditory processing skills and neural functioning, leading to improvements in real-world communication. While challenges remain, the future of CAPD intervention looks promising, with the potential to help children with CAPD overcome their difficulties and succeed in noisy, language-rich environments.

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Book Review

Title: Forensic Audiology.
A Guide for the expert witness.

Authors: Robert M. Traynor & Krista B. Traynor.
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Reviewed by Rashmi J. Bhat

This book is truly a masterpiece. As a guide, it has not left any area unexplored and is a must read for any audiologist who aspires to expand his/her scope of practice to Forensic audiology. It gives a comprehensive and in-depth description of the US legal system and the potential roles the audiologist may play as a witness as well as a consultant. Borrowing the words of Michael Metz from the foreword, this is a textbook which is highly relevant and is one that will not just sit on a shelf. Having said that, for the Indian reader, it may appear unfamiliar as the system is different from that followed in our country. However, for a person who is keen to get an understanding of legal parlance, this will be the 'go to' volume with engaging examples and case vignettes.

The field of audiology is continuously evolving. Indian audiologists need to have a clear knowledge of the process involved, responsibilities and the etiquette to be followed if they want to venture into the new arena of Forensic Audiology (FA). Competency in theory/subject knowledge is vital, but the legal process requires a completely different set of skills which we do not learn as students. Even though the term "Forensic Audiology" is heard often, the ramifications of terms and procedures involved are hazy. This textbook gives answers to many of the queries a student would have had while listening to the classes on FA.

The book has 9 chapters which generally cover three main areas-chapters 1-3 form the basis or foundation, chapters 4-7 describe the legal structure/ procedure and terminologies and chapters 8 and 9 specifically look at practice development as well as code of conduct for the Forensic Audiologist. In Metz's words "Competence comes through experience, and experience comes through mistakes," this book will help the individual avoid making costly mistakes.

The prologue offers a brief glimpse into how the legal system has evolved over the centuries in the US. History indicates that when judges found themselves unable to comment on a specific issue in a legal proceeding, due to inadequate scientific background, a need for the services of the Expert witness was felt. The prologue introduces terms such as expert juror, consultant and witness. A nice touch is the case study of Folkes vs Chadd (1782/83) that takes the reader through the process in steps, this also happens to be the first use of an expert witness in England.

Chapter 1 provides an **Introduction to Forensic Audiology** in 20+ pages. The authors highlight how an expert witness amalgamates his scientific knowledge, experience and research abilities to find evidence that will help solve civil/ criminal cases. Here again, there is reiteration of the need of understanding the "ethos" of the legal community before venturing into being an expert witness as well as having mandatory professional certification. Analogies from other fields and specific examples from Audiology are used to simplify the concept as well as retaining the interest of the reader. Though for the Indian reader the applicability may appear somewhat unclear, the clarity of thought and systematic method followed elsewhere in the world is important to understand and emulate. The chapter also traces the contribution of the current Doctor in Audiology degree in expansion of scope of practice to Forensic Audiology. Further it throws light on how attorneys select expert witness, what they expect out of them and the qualities that are essential to be a witness. This chapter sets the tone for what is to follow in the next chapters.

In Chapter 2, the authors explain the **Rules of Expert testimony**. Mention is made of the Frye (1923) rule which had several limitations, followed by Daubert rule of 1993 that clarifies which kind of expert testimony is admissible in court as evidence. Three cases that make up the Daubert trilogy are presented to give the reader an insight into how the lawmakers arrived at the current scenario in terms of admissibility of evidence. Handy pointers for attorneys (boxes 2.3, 2.4, 2.5) for challenging the witnesses, arguments and attacking the witnesses will help the future Forensic Audiologist to be fully equipped before appearing in court.

Chapter 3 describes the **United States court system** and its history. This section reads like a tutorial for residents and practitioners within the US. However, elsewhere in the world, the process may not be similar and thus will be added on knowledge. The different types of courts such as ordinary, superior, court of limited jurisdictions etc. have been explained in detail along with the various levels such as district, state, federal and supreme courts. A Forensic Audiologist in the US needs to be mandatorily aware of the nuances and workflow as procedures may differ across these platforms. Descriptions of civil vs criminal cases are provided, which is definitely a must for a Forensic Audiologist to know and understand. The role Forensic Audiologists will play no matter which side they are (hired by the plaintiff or the defendant), their objectivity and non-prejudicial investigation capacity is emphasized. The authors have gone to great trouble to simplify the complex legal system of US. Table 3.2 is a handy summary of the jurisdiction of various courts, for an aspiring Forensic Audiologist.

Chapters 4 and 5 focus on procedurals for **Criminal and civil cases.** Comprehensive definitions and classifications of both acts with multiple examples are presented. The punishments that are to be accorded for the different degrees of crimes are also clearly demarcated. The factors that contribute while deciding the severity of the crime are mentioned. Authors also explain the term “beyond reasonable doubt” in a succinct manner. Box 4.2 covers this aspect with two case scenarios. Further, the rights of the convict are delineated. The reader is also taken through the journey of jury selection in a step-by-step manner. Responsibilities of the jury, legalese such as plaintiff/victim, defendant, paralegal, bailiff, varieties of witnesses (such as lay/character/secondary/expert) are defined. The path followed from arraignment till verdict is drawn very clearly for a criminal case. The reader also gets to understand the follow up after conviction such as “appeal, probation and parole” etc. The reader will also realize that steps followed in civil litigation are slightly different but diligent and systematic. (Box 5.1 gives 2 case scenarios as examples of civil cases).

Chapter 6 covers a topic that is vital to professionals - writing **Legal reports** and the nuances of documentation pertaining to the case of which they are a part. Authors reiterate here about the necessity of using one's training, experience and expertise to objectively analyze the data available impartially. Reviewing medical reports, audiological reports and any other necessary documents without bias is emphasized. The fact that the report must follow a specified structure, should provide current research evidence pertaining to the issue *and* should be the expert's own conclusion without encroaching on any other expert's purview is reiterated here.

Chapter 7 gives an idea on how attorneys prepare for the trial focusing on '**Discovery-Deposition-Trial**.' The discovery process (review of all documents/ audio or video recordings or any other information that is beneficial to the case) leads them to possible outcomes and perhaps followed by a written interrogatory which the other side must answer within 30 days. During this process, the Forensic Audiologist may be used as a consultant to clarify the attorney's queries, may help in preparing a line of questions to arrive at the truth or simply review the test reports and suggest further tests for clear understanding of the situation. Further, they also may have to depose (answer questions under oath but not in court). At this juncture, the reader is given pointers to avoid pitfalls, and how not to appear inconsistent and testify only to those facts that they know. Thus, this chapter is a bird's eye view of the 'who/where, when, why and how' of the proceedings in court and pre-trial activities. For me, the main take home in this chapter was the awareness/ understanding that one never can be careful enough and being complacent will lead us into a quagmire. Being credible needs a lot of preparation and awareness of the process and this chapter helps one to understand the importance of the same.

Chapter 8 covers the **FA practice development**. It mentions a B2B (business to business) model where the Forensic Audiologist markets themself to the retaining attorneys. The authors remind the reader that certain protocols have to be followed as one is offering a professional service. Box 8.2 gives pointers on how attorneys locate and select expert witnesses: these are requirements one has to meet before offering his/ her services as FA.

Chapter 9 is the most important and a fitting end to the book covering **Ethics of Expert Witnessing**. It makes the responsibilities of the FA clear, explicitly states that one must evolve with technology, tools, laws and contexts. One has to be bound by professional code of conduct of the national bodies such as ASHA, ADA, AAA in addition to the Forensic Expert Witness Association. The chapter concludes with few tips /practice essentials to prevent violations of the professional code of ethics.

Further the appendix lists out the Code of ethics for the three most important associations for the US practitioner, ASHA, ADA, AAA, 2023 versions.

In summary, the authors bring more than 5 decades of their experience in the field in a simple and straight forward manner to the naïve reader. The book has loads of information presented in an engaging manner in-spite of the fact that the topic is dry. Lucid descriptions ably supported by apt examples will definitely hold the attention of the reader. On a lighter note, I am able to understand the legal thrillers that come out of the US much more easily. It's much needed information provided in a nutshell. I recommend all PG students to read this to explore a possible career as a Forensic Audiologist in the future.

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