



Assessment of Auditory Awareness among Hearing Aids Users in Calabar Municipal Local Government Area of Cross River State, Nigeria

EDWIN. O. BASSEY
National Open University of Nigeria

BERNARD DIWA OTU
University of Calabar, Cross River State, Nigeria.

Abstract. Assessment of auditory awareness among hearing aids users in Calabar Municipal Local Government Area of Cross River state, Nigeria. To achieve the aim of this study, four research questions were formulated to guide this study. Literature related to the variables under study was reviewed according to the hypotheses for the study. Survey research design was adopted for this study. The essence of this design was to allow the researcher make inference and generalization of the population by selecting and studying the sample chosen for the study. A total sample of two hundred and twenty (120) respondents were randomly selected for the study. The selection was done through the accidental sampling technique. The main instrument used for the collection of data was the questionnaire titled Assessment of Auditory Awareness questionnaire (AAAQ). The questionnaire was subjected to face validity by two experts in Measurement and Evaluation/Research and Statistics and Faculty of Education who vetted the items developed. The reliability estimate of the instrument was established through the Cronbach Alpha reliability method. The data were collected personally by the researchers with the help of some research assistants. To analyze the data for the study, descriptive statistics of mean and standard (simple percentage) was adopted this was because of the nature of the variables involved in the study. The result of the analysis reveals that, the level of sound detection among hearing aids, sound localization, auditory attention level and sound discrimination among hearing aids users in Calabar Municipal is significantly positive. Based on the findings of the study, it was recommended that auditory hearing aids should be provided to users.

Keywords: Auditory Awareness, Hearing Aids, Hearing Aids Users, Sound Localization, Auditory Attention, Calabar Sound Discrimination.

1. Introduction

The function of the auditory organ is to discriminate among sounds and filter in the most meaningful sound for effective communication. The inability of the auditory organ to perform such function naturally, the need for hearing aids. The ear is the organ of hearing and balance. It is the 8th cranial nerve, which is stimulated by vibration caused by sound waves. With the exception of the pinna (auricle), the structure that forms the ear is enclosed within petrous the portion of the temporal bone. The ear is divided into three parts the outer ear, the middle ear (for hearing), and the inner ear (for balancing) (Grant & Waugh, 2010), when there is no coordination between the three parts of the ear, the resultant effect is hearing loss or hearing problem.

The human ear can generally hear sounds with frequencies between 20 Hz and 20 kHz (the audio range). Sounds outside this range are considered infrasound (below 20 Hz) (Greinwald, 2002) or ultrasound (above 20 kHz). Although hearing requires an intact and functioning auditory portion of the central nervous system as well as a working ear, human deafness (extreme insensitivity to sound) most commonly occurs because of abnormalities of the inner ear, rather than in the nerves or tracts of the central auditory system.

An ear is the organ that enables hearing and, in mammals, body balance using the vestibular system. In mammals, the ear is usually described as having three parts—the outer ear, the middle ear and the inner ear. The outer ear consists of the pinna and the ear canal. Since the outer ear is the only visible portion of the ear in most animals, the word "ear" often refers to the external part alone (Susan 2008). The middle ear includes the tympanic cavity and the three ossicles.

The inner ear sits in the bony labyrinth, and contains structures which are key to several senses: the semicircular canals, which enable balance and eye tracking when moving; the utricle and saccule, which enable balance when stationary; and the cochlea, which enables hearing. The ears of vertebrates are placed somewhat symmetrically on either side of the head, an arrangement that aids sound localisation. The ear develops from the first pharyngeal pouch and six small swellings that develop in the early embryo called otic placodes, which are derived from ectoderm. The ear may be affected by disease, including infection and traumatic damage. Diseases of the ear may lead to hearing loss, tinnitus and balance disorders such as vertigo, although many of these conditions may also be affected by damage to the brain or neural pathways leading from the ear. The ear has been adorned by earrings and other jewelry in numerous cultures for thousands of years, and has been subjected to surgical and cosmetic alterations.

A hearing aid is a device designed to improve hearing by making sound audible to a person with hearing loss. Hearing aids are classified as medical devices in most countries, and regulated by the respective regulations. Small audio amplifiers such as personal sound amplification products (PSAPs) or other plain sound reinforcing systems cannot be sold as "hearing aids". Early devices, such as ear trumpets or ear horns (Bentler, 2000) were passive amplification cones designed to gather sound energy and direct it into the ear canal. Modern devices are computerised electroacoustic systems that transform environmental sound to make it audible, according to audiometrical and cognitive rules. Modern devices also utilize sophisticated digital signal processing to try and improve speech intelligibility and comfort for the user. Such signal processing includes feedback management, wide dynamic range compression, directionality, frequency lowering, and noise reduction.

Modern hearing aids require configuration to match the hearing loss, physical features, and lifestyle of the wearer. The hearing aid is fitted to the most recent audiogram and is programmed by frequency. This process is called "fitting" can be performed by the user in simple cases, or is performed by a Doctor of Audiology, also called an audiologist (AuD), or by a Hearing Instrument Specialist (HIS) or audioprosthologist. The amount of benefit a hearing aid delivers depends in large part on the quality of its fitting. Almost all hearing aids in use in the US are digital hearing aids, as analog aids are phased out (Kochkin, 2010). Devices similar to hearing aids include the osseointegrated auditory prosthesis

(formerly called the bone-anchored hearing aid) and cochlear implant.

Hearing aids are used for a variety of pathologies including sensorineural hearing loss, conductive hearing loss, and single-sided deafness. Hearing aid candidacy was traditionally determined by a Doctor of Audiology, or a certified hearing specialist, who will also fit the device based on the nature and degree of the hearing loss being treated. The amount of benefit experienced by the user of the hearing aid is multi-factorial, depending on the type, severity, and etiology of the hearing loss, the technology and fitting of the device, and on the motivation, personality, lifestyle, and overall health of the user (Cox, 2016). Over-the-counter hearing aids, which address mild- to moderate- hearing loss, are designed to be adjusted by the user (Cox, 2016).

Hearing aids are incapable of truly correcting a hearing loss; they are an *aid* to make sounds more audible. The most common form of hearing loss for which hearing aids are sought is sensorineural, resulting from damage to the hair cells and synapses of the cochlea and auditory nerve. Sensorineural hearing loss reduces the sensitivity to sound, which a hearing aid can partially accommodate by making sound louder. Other decrements in auditory perception caused by sensorineural hearing loss, such as abnormal spectral and temporal processing, and which may negatively affect speech perception, are more difficult to compensate for using digital signal processing and in some cases may be exacerbated by the use of amplification (Brian, 2007). Conductive hearing losses, which do not involve damage to the cochlea, tend to be better treated by hearing aids; the hearing aid is able to sufficiently amplify sound to account for the attenuation caused by the conductive component. Once the sound is able to reach the cochlea at normal or near-normal levels, the cochlea and auditory nerve are able to transmit signals to the brain normally. Common issues with hearing aid fitting and use are the occlusion effect, loudness recruitment, and understanding speech in noise. Once a common problem, feedback is generally now well-controlled through the use of feedback management algorithms.

Hearing problems are common but they might be disastrous if proper care is not taken. The treatment procedure for different hearing problems might vary. It is necessary to contact a health care provider to get the right treatment. Primary causes of ear disorders include common cold, injury, foreign body in the ear, and swimming, long-term exposure to excessive noise, congenital, auto toxic drugs (Grant & Waugh,

2010). Most of these causes listed above have been in existence over the years.

According to Eisenberg, Johnson, Martinez, Visser-Dumont, Ganguly and Still (2012), hearing loss can create hearing disability in people and consequently exposes them to the need for a hearing aid. Hearing loss can have a significant impact on someone's life, from individual work to personal relationships and emotional well-being. A hearing aid is a device designed to improve hearing by making sound audible to a person with hearing loss. Hearing aids are classified as medical devices in most countries, and regulated by the respective regulations.

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Modern hearing aids require configuration to match the hearing loss, physical features, and lifestyle of the wearer. However, hearing and communication skills are distinct features of the human existence, considered the greatest contributors for the well-being of any individual. The auditory sensory deprivation affects the development of the hearing function and the oral language, and may result in emotional, educational, social, and cultural implications (Starr, Picton, Sininger, Hood & Berlin, 2016).

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of the earpiece used by teenagers is another danger that may cause ear problems, and perforation of the eardrum either by sharp objects, improper curretting or syringing. The damage may also occur due to direct violence like slap (Ochen, 2015).

Auditory awareness describes a person's ability to perceive and make sense of what's going on around them through sound. When sound waves hit the ear, these vibrations are communicated to and translated by the brain. Auditory awareness can also be described as a combination of three subsets of skills: detection, localization and auditory attention. Logically, auditory awareness plays a very important role in our day-to-day lives, being present in almost every task we perform. If allow, it is to properly interact with our environment, communicate fluently, alert us of any potential threats around us, and makes it possible to enjoy music. Auditory awareness allows us to do many daily activities effectively and quickly.

Though there are facilities for treatment of hearing problems, a number of cases of hearing problems are still found in some areas due to low level of awareness or illiteracy by parent (in the cases of children), misinformation, social and cultural factors, political barriers, geographical distance and logistic barrier.

This study became necessary because in spite of the effort of government, non-governmental organizations, parents and school authorities, to improve the auditory abilities of people with hearing problem through the use of hearing aids, it has been observed that there are still reported cases of poor auditory awareness and sound discrimination among hearing aids users. People with attention deficit disorder, auditory processing disorder, autism spectrum disorder and others may find it difficult to attend to a spoken message in the presence of background noise. Consequently, this work is carried out to critically assess auditory awareness among hearing aids users in Calabar municipality.

2. Literature Review

2.1 Sound detection among hearing aids users

Sound detection is the discrimination of sound from background noise, either by ear or by electronic instrument. Detection is the most basic of listening tasks, as it requires the listener to determine the presence or absence of sound, or of a particular sound. For children who have typical auditory development, detection of sound begins in the third trimester of pregnancy and continues to develop during the first year of life: Werner (2007). A student's audiologist

should ensure that the device settings allow the student access to the full range of speech sounds accessible to the student, these settings can become less effective over time.

The perception of sound level is fundamental to hearing our environment and in treating hearing impairment, from restoring dynamic range to achieving comfortable levels of gain in a hearing aid. The ability to discriminate the levels of different sounds is vital to our perception of the environment (Brungart et al, 2001) as well as communication (Mitchell et al., 2003). The effect of hearing impairment (HI) and amplification on this ability has, however, only been experimentally tested with pure tones or, in rare circumstances, noises. Little is known about how well hearing-impaired populations, with or without hearing aids, judge the level of realistic sounds or how hearing aids affect this ability.

Spatial hearing permits a listener to identify the locations of sound sources and it aids in detection and recognition of sounds in the presence of other competing sounds. Hearing aids work by amplifying sound through a three-part system: The microphone receives sound and converts it into a digital signal. The amplifier increases the strength of the digital signal. The speaker produces the amplified sound into the ear. A hearing aid is a device designed to improve hearing by making sound audible to a person with hearing loss. Hearing aids are classified as medical devices in most countries, and regulated by the respective regulations.

Early devices, such as ear trumpets or ear horns,^{[1][2]} were passive amplification cones designed to gather sound energy and direct it into the ear canal, Bentler (2000). Modern devices are computerised electroacoustic systems that transform environmental sound to make it audible, according to audiometrical and cognitive rules. Modern devices also utilize sophisticated digital signal processing to try and improve speech intelligibility and comfort for the user. Such signal processing includes feedback management, wide dynamic range compression, directionality, frequency lowering, and noise reduction Bentler (2000).

In a research on auditory disability, Noble and Gatehouse (2006) found that aided participants reported that sounds were perceived much more as being located inside the participant's head (*i.e.*, internalized) than unaided participants. A possible cause for this internalization problem is the hearing-aid compressor. The hearing-aid compressor, however, is its vital component; it attempts to compensate for the loss in dynamic range. This

technology, along with other hearing aid technology (*e.g.*, noise reduction), depends on proper estimations of the acoustic environment. To better inform how hearing aids can make relevant estimations of the levels of everyday sounds, it is necessary to know how the relative levels of everyday sounds are perceived by hearing-aid wearers, and how current hearing aids impact their judgment.

The healthy, young auditory system can detect tones in quiet with frequencies ranging from approximately 20 to 20000 Hz. The sounds to be detected can be presented over calibrated headphones (minimal audible pressure, MAP, measures) or from a loudspeaker in a calibrated free-field environment (minimal audible field, MAF, measures). The headphones can be circumaural, that is, with a headphone cushion that fits around the pinna and the earphone speaker resting against the outside of the outer ear canal, or they can be insert earphones whose earphone loudspeaker fits within the outer ear canal (Mitchell et al., 2003).. The thresholds are expressed in terms of decibels of SPL, where zero (0) dB SPL means that the sound pressure level is 20 micropascals (*i.e.*, the referent sound pressure (p_{ref}) is 20 micropascals). Thus, the dynamic range of hearing covers approximately 130 dB in the frequency region in which the human auditory system is most sensitive (between 500 and 4000 Hz). The thresholds for detecting a tonal sound increase as the duration of the sound to be detected decreases at durations shorter than 500 ms, but remain approximately constant as the duration increases above 500 ms (Mitchell et al., 2003).

Moreso, as sound travels from its source to the outer ears of a listener, it passes over and around (is diffracted by) many parts of the body, especially the pinna. These body parts attenuate and slow down the sound wave in a manner that is specific to the frequency of the sound and to the relationship between the location of the sound source and the body, especially the relative vertical location of the source. The head-related transfer function (HRTF) describes the spectral changes that a sound undergoes between the sound source and the outer ear canal, Mackle (2016). High-frequency sounds are attenuated in a frequency-specific manner that is dependent on the vertical location of the sound source relative to the body. That is, different HRTFs are produced for different vertical sound source locations. In particular, there are spectral regions of low amplitude (spectral notches or valleys) whose spectral loci are vertical-location-specific. Thus, these spectral notches in the HRTF can be a cue for vertical location. The spectral cues associated with the HRTF are probably also used

to help discriminate sounds that come from in front of a listener from those that come from behind, Ochen (2015). For instance, a sound coming from directly in front of a listener will provide the same interaural time and level differences as a sound coming from directly behind. Spectral cues derived from the HRTF can assist in reducing front-back localization errors.

Faraway sounds are usually softer than near sounds, and this loudness cue can be used to determine the distance of a sound source, assuming the listener has some knowledge about the nature of the source (i.e., some knowledge about how intense the sound is at the source). If there is any reflective surface (e.g., the ground), then the reflection from a near sound source is almost as intense as the sound that arrives at the ears directly from the source, whereas for a faraway sound the reflected to direct sound level ratio is lower. Thus, the ratio of reflected to direct sound level can be a cue for sound source distance perception, and distance perception is poorer in conditions in which there are no reflections, Nyam (2014).

Therefore, the detection of a signal sound source at one spatial location in the presence of a masking sound source at another spatial location is improved when the signal and masking sound sources are further apart. That is, the ability to detect a masked signal can be enhanced if the masking sound source is spatially separated from the signal sound source. The improvement in detection threshold as a function of spatial separation is referred to as the spatial masking-level difference. Thus, a variable that could affect speech recognition is the spatial separation of the test signal and other sound sources in the listening environment. Patients fitted with two hearing aids can sometimes take advantage of detecting sounds based on their spatial separation, whereas this becomes more difficult if the patient only uses one hearing aid, (American National Standards Institute, 2003).

Empirically, McCain and Kim (2012) suggested a correlation between specific sensorineural hearing loss, with a predictable decrease in hearing levels at the 1000 to 2000 Hz range, and TMJ dysfunction or parafunction, or both. In the authors' experience, all patients regained normal hearing levels within 2 months postoperative. This confirms the fact that arthroscopy does not affect hearing levels if no direct trauma to the middle ear has occurred. Ensuring that the scope is not advanced past 20 to 25 mm without accurately checking its position will prevent the occurrence of this complication (McCain & Kim, 2012).

3. Sound localization among hearing aids users

Sound localization is the process of determining the location of a sound source. The brain utilizes subtle differences in intensity, spectral, and timing cues to allow us to localize sound sources, Thompson et al. (2005). Sound localization is a listener's ability to identify the location or origin of a detected sound in direction and distance. The sound localization mechanisms of the mammalian auditory system have been extensively studied. The auditory system uses several cues for sound source localization, including time difference and level difference (or intensity difference) between the ears, and spectral information. These cues are also used by other animals, such as birds and reptiles, but there may be differences in usage, and there are also localization cues which are absent in the human auditory system, such as the effects of ear movements. Animals with the ability to localize sound have a clear evolutionary advantage.

Sound localization, the ability to locate the source of a sound, begins to develop within the first seven months of life and continues to improve as the child has more experience with hearing and listening. When localizing a sound, the brain compares the relative loudness of the sound at each ear. Sounds that originate from the right or left side of a person are easier to locate than sounds originating from in front or behind. Individuals with unilateral or imbalanced hearing loss (including imbalanced hearing levels with hearing devices) may have more difficulty locating the source of a sound.

Sound localization is important during class discussions and conversations with multiple people. Difficulty localizing can have academic consequences, as time and effort spent locating the talker reduces attention to the message and delays the support received from visual cues such as speech reading. Localization of environmental sounds can also be a safety issue in sports, traffic and other environments.

Under difficult listening conditions, or for a hearing-impaired person, localization can play a vital part in understanding group conversations. When the conversation switches from one person to another, the listeners need to locate the new speaker instantly or they will miss the first part of each segment of the conversation, which may seriously reduce understanding. This is especially so for people with substantial hearing loss who typically rely on a lot of help from speech reading. Impaired localization probably plays a more significant role in speech

communication difficulties than is usually appreciated.

It has been suggested (e.g. Hirsh, 2015) that there is a direct connection between the ability to localize sounds and the ability to hear speech in noise. The basis of this argument is that interaural phase differences are cues for both localization and release from masking (i.e. masking level differences). However, no strong link between these abilities has ever been demonstrated and a recent study showed only weak correlations between localization and the ability to separate speech from noise (Noble et al, 2007). This issue requires further investigation and, at present, it seems an open question whether there is any direct connection between impaired localization and difficulty in recognizing speech.

Localization has a horizontal (azimuth) and a vertical (elevation) component. Horizontal localization depends mainly on interaural difference information. A sound on the right side of the head will reach the right ear (near ear) a bit sooner than it will reach the left ear (far ear). It will also be slightly louder in the right ear and will have a slightly different spectrum because the head shadow will selectively attenuate the higher frequencies at the left ear. Interaural time differences are usually the most dominant cue for horizontal localization (Wightman and Kistler, 2002) provided that the signal has audible components at frequencies below 1500 Hz. At higher frequencies, phase and time differences in the waveform become ambiguous. However, interaural intensity differences, which occur mainly for frequencies above 1500 Hz, may become the dominant localization cue when time differences are unavailable.

Spectral cues also have some role in horizontal localization especially in discriminating front from rear sound sources (Musicant and Butler, 2014). For example, if a sound is on one side and in front of a listener, the high frequency components of the signal received at the near ear will have a relatively greater intensity than they would if the sound were at the same distance from but to the rear of the listener. Thus, for sounds located at the same elevation, changes in azimuth (horizontal direction) result in changes in the spectrum of the sound received at the near ear because of reflections and shadowing caused by the pinna. Similarly, direction-dependent spectral changes occur at the far ear because of head shadow as well as pinna effects. These spectral changes can provide a monaural cue for horizontal localization in addition to the binaural cue provided by the interaural difference in the spectra of signals received at the two ears.

The main cue for median plane vertical localization (i.e., facing the sound source). When a sound strikes the pinna (external ear) it is subjected to a complex pattern of reflections which alter the high frequency spectrum of the sound reaching the eardrum. These pinna reflections, and hence the spectrum of the sound in the ear canal, vary with the elevation of the sound source. For example, the most pronounced notch in the ear canal sound spectrum tends to become higher in frequency as the elevation of the sound source becomes greater (Hebrank and Wright, 2014). These elevation-dependent changes in spectrum occur at frequencies above 4000 Hz and provide the major vertical localization cue. When sounds are not in the median plane, interaural time and intensity differences provide additional cues for elevation.

Sound localization per se probably is the best understood, and that will be the main topic of this chapter. In most natural listening conditions, normal human listeners can localize sounds within a few degrees of accuracy in both horizontal and vertical dimensions (Stevens and Newman, 1936; Makous and Middlebrooks, 1990; Carlile et al., 1997; Yost et al., 2013).

Sound localization is a special challenge for the auditory system. In the visual and somatosensory systems, stimulus location is mapped directly on the sensory surfaces, i.e., the retina and the skin, respectively. In the auditory system, it is frequency that is mapped on the cochlear sensory surface, not location. Sound location must be inferred from spatial acoustic cues that arise from the physical interactions of sounds with the head and external ears. Those cues must be analyzed within the central auditory system and, in some way, integrated to create a neural representation of auditory space. We will see that this is not possible in every stimulus condition: examples are failures of horizontal localization of tones with frequencies around 3 kHz and failures of vertical or front/back localization of any sound that is restricted in bandwidth.

In reverberant spaces, such as a room, the sound waveform reflects off the many surfaces, resulting in a complex pattern of sound arriving at the ears of a listener. Listeners are usually not confused about the nature of the actual sound source, including its location, in many reverberant spaces, presumably because the auditory system processes the first sound arriving at the ears and inhibits the information from later-arriving reflected sounds. Since the sound from the source will arrive at the listener before that from any longer-path reflection, auditory processing of the direct sound takes precedence over that of the reflected

sound, usually allowing for accurate sound processing even in fairly reverberant environments. Another aspect of sound reflections is that the sound in a reflective space remains in the space after the sound production ends, due to the sound continuing to reflect off the many surfaces. The reverberation time is the time (measured in seconds) that it takes the level of this reverberant or reflected sound to decay by a specified number of decibels, which is usually 60 dB. Rooms that are large and reflective have long reverberation times. People with hearing losses often perform very poorly in reverberant spaces, and the poor performance may persist even when they use a hearing aid or cochlear prosthesis. That is, people with hearing loss have difficulty recognizing speech signals when the reverberation time is long, especially if the acoustic environment is also noisy, Yost et al., (2013).

Empirically, sound waves come into the outer ear and hit the eardrum, causing the eardrum to vibrate (Willacy, 2018). Behind the eardrum are three tiny bones (ossicles). The vibrations pass from the eardrum to these middle ear bones. The bones then transmit the vibrations to the cochlea in the inner ear. The cochlea converts the vibrations to sound signals which are sent down a nerve to the brain, which we 'hear'. The middle ear behind the eardrum is normally filled with air. The middle ear is connected to the back of the nose by the Eustachian tube. This allows air in and out of the middle ear (Willacy, 2018).

4. Auditory attention and hearing aids users

The hearing process is a series of processes involved in listening skills, including attention, memory, sound detection, location, figure-ground, among others (Cavadas, 2007). Sauer, (2006) reports that individual with learning difficulties, have poorer performance on alertness, suggesting delayed maturation of auditory processing skills. Attention is a multimodal process, essential for development and learning and the acquisition of language, not only on aspects relating to the field of linguistic structures, but also in the development of communication skills that allow the hearing aids users to participate in a conversation, talk about a topic or tell a story, Gomes (2000)

The auditory attention is a cognitive process that allows the listener to focus selectively on the stimulus of interest, a stimulus while ignoring irrelevant competing, so the listener consciously selects the stimulus which he will watch and process its response (Medwetsky, 2002)

The auditory attention of students can be influenced by hearing impairment, causing impairment in attention and comprehension skills and thus compromising the

performance and learning of these children. Thus, it became essential to realization of audiometry and impedance prior to application of SAAAT (Araújo, 2002).

The association between the ability of attention and learning raised by some authors (Neves, 2005, and Sauer, 2006), shows that academic performance is strongly affected when the child has no ability to concentrate to a target stimulus, for a given period of time. This attention deficit will affect these children in the communication skills necessary for the acquisition of oral language as well as in written language acquisition (Silva, 2005).

Importantly, the identification of difficulties in processing auditory verbal and nonverbal children in preschool and school has affirmed its importance in academic foundations, maturational, psychological, and economic. Early identification of children with serious skills auditory information processing reduces time and costs of intervention (Kelly, 2005). Thus, considering that one of the leading causes of school failure among people is the lack of attention (Lemos, 2007), as this is essential for learning new skills, oral and written communication, and learning as described above, to assess the sustained auditory attention ability is of utmost importance.

Auditory Attention is often discussed as a figure-ground task – the ability to attend to a spoken message in the presence of competing background noise. The *Where's Waldo* challenges are a visual figure-ground task. Focusing on a specific voice in a sea of other human voices can be compared to searching for Waldo in a scene of similarly clad people, Gomes, et al (2000).

When an individual is in a room full of people chatting in small groups, she filters out the conversations around her in order to focus on her own small group. The irrelevant speech become a low rumble as if it were distant thunder. Although this focused listening seems to happen without effort, it does require cognitive resources and listening effort to attend to a single stream of speech in a sea of spoken language.

Students with reduced hearing levels are not the only ones who can struggle with auditory attention. Students with attention deficit disorder, auditory processing disorder, autism spectrum disorder and others may find it difficult to attend to a spoken message in the presence of background noise. Ability to attend can be affected by multiple factors, such as amount of sleep, nutrition, bodily comfort, emotional state, motivation, and interest in the topic, to name a

few. Gomes, et al (2000) describe four types of auditory attention: arousal, orientation, selective attention and sustained attention. Each of these are important for academic success. When students are working in small groups and the teacher begins talking to the whole class, each student needs to rouse to the teacher's voice (arousal), shift attention from the conversation in the small group and focus on what the teacher is saying (orientation). Often, other students or groups of students do not cease talking in order to listen to the teacher. When this happens, the amount of background noise adds to the difficulty of focusing on the teacher's message (selective attention). In addition to being alerted by the teacher's voice and shifting attention, the student needs to be able to sustain attention for the duration of the teacher's discourse or group conversation. Auditory attention is just one way of attending to an activity – but it may be the most important part of attention at school. Consider the amount of information shared in the classroom by students and teachers using spoken language. Any student with poor auditory attention will be at a great disadvantage, Gomes, et al (2000).

Moreso, just as listening to a single person speaking in a crowded room while several other conversations and background sounds are present is a demanding but very common situation. In acoustic scenes like this, comprising multiple competing sound sources, the auditory system parses complex auditory input into perceptual components and constructs the incoming sound sources into aggregated signals called acoustic streams (Bregman, 1990). Similar to focusing on specific objects of interest in crowded visual scenes, auditory attention helps us to selectively pick out single acoustic streams to listen to (Best et al., 2008; Shinn-Cunningham, 2008). Due to the importance of auditory attention in our day-to-day life, research into both underlying mechanisms and consequences for sensory processing remain areas of high interest. Attention to auditory streams can either be voluntary and goal-driven (endogenous, top-down), e.g., enabling a listener to follow a single speaker in a multi-conversation environment or exogenously triggered. Exogenous attention is stimulus-driven and involuntary (bottom-up) and results in capturing and orienting of attention toward sudden, salient stimuli (Chun et al., 2011; Awh et al., 2012). Capture may be evoked by potentially important sounds and force attention to specific auditory streams or sources, e.g., “looming” of an approaching object that has been shown to increase the speed and accuracy of source localization (McCarthy and Olsen, 2017). In multi-stream auditory scenes, auditory stimuli that capture attention have been shown to degrade perceptual processing of a target stream (e.g., Schröger,

1996; Dalton and Lavie, 2004, 2007; Dalton and Hughes, 2014). Studies from the visual domain indicate that there are both benefits and costs to exogenous attention, Carrasco, 2011; Seifried and Ulrich, 2011; Chica et al., 2013).

Selective auditory attention or selective hearing is a type of selective attention and involves the auditory system. Selective hearing is characterized as the action in which people focus their attention intentionally on a specific source of a sound or spoken words. When people use selective hearing, noise from the surrounding environment is heard by the auditory system but only certain parts of the auditory information are chosen to be processed by the brain. Acoustical Society of America (2012). Most often, auditory attention is directed at things people are most interested in hearing Bess (2008). Selective hearing is not a physiological disorder but rather it is the capability of humans to block out sounds and noise. It is the notion of ignoring certain things in the surrounding environment. The dividing line between preference and utility is not clear cut. Selective auditory attention differs from selective perception, in that the filtering in the latter case is mediated by cognitive dissonance. In an article by Krans, Isbell, Giuliano, and Neville (2013), selective auditory attention is defined as the ability to acknowledge some stimuli while ignoring other stimuli that is occurring at the same time. An example of this is a student focusing on a teacher giving a lesson and ignoring the sounds of classmates in a rowdy classroom. This is an example of bottlenecking which means that information cannot be processed simultaneously so only some sensory information gets through the "bottleneck" and is processed. A brain simply cannot process all sensory information that is occurring in an environment so only the most relevant and important information is thoroughly processed by the brain (Karns 2015). There have been some models that theorize the pathway of selective auditory attention, notably the early selection model, late selection model, and attenuation model.

Recently, researchers have attempted to explain mechanisms implicated in selective auditory attention. In 2012, an assistant professor in residence of the Neurological Surgery and Physiology in the University of California San Francisco examined the selective cortical representation of attended speaker in multiple-talker speech perception. Edward Chang and his colleague, Nima Mesgarani undertook a study that recruited three patients affected by severe epilepsy, who were undergoing treatment surgery, Mesgarani (2012). All patients were recorded to have normal hearing. The procedure of this study required

the surgeons to place a thin sheet of electrodes under the skull on the outer surface of the cortex. The activity of electrodes was recorded in the auditory cortex. The patients were given two speech samples to listen to and they were told to distinguish the words spoken by the speakers. The speech samples were simultaneously played and different speech phrases were spoken by different speakers. Chang and Mesgarani found an increase in neural responses in the auditory cortex when the patients heard words from the target speaker. Chang went on to explain that the method of this experiment was well-conducted as it was able to observe the neural patterns that tells when the patient's auditory attention shifted to the other speaker. This clearly shows the selectivity of auditory attention in humans.

5. Sound discrimination among hearing aids users

Sound discrimination is the ability to recognize similarities and differences between sounds. Mainly, sound discrimination allows people to distinguish between phonemes in words. Phonemes are the smallest units of sound in any given language. Sound discrimination allows someone to tell the difference between words and sounds that are similar and words and sounds that are different. The most basic level of auditory discrimination is hearing the difference between sounds in our environment, e.g., identifying the sound of a car passing, the noise of a fan turning, etc. The children should progress to identifying more closely linked sounds, e.g., different people's voices or the difference between a car and a truck, Kung (2005).

Sound discrimination is very important to early readers and writers, because when a child wants to write the words "pig" or "bat," it will be very important to be able to identify all of the sounds in those words. Otherwise, reading and writing small words like these will be impossible without memorizing every what every single word looks like, right down to the last letter. Imagine trying to write long words such as "encyclopedia" without being able to separate that word into syllables in your head as you write it down! You would be relying only on memory to spell these long words, and might forget a letter or two. Kids that learn to listen for and distinguish between each syllable and letter sound in the words that they read have a much better chance of reading and writing well than those that do not. In addition, rhyming is a foundational skill for language arts, and depends entirely on sound discrimination. Phonics in general is also highly dependent on sound discrimination skills as well. Auditory discrimination

tests (ADTs) are one type of auditory analysis tests, which are used to measure how well a child understands speech and the spoken word. ADTs are designed to measure a child's phonological awareness—the ability to focus on and manipulate phonemes within spoken words.

Sound discrimination among hearing aids users is very critical as it helps them differentiate and produce the short / I / sound as in 'milk' and the longer / i: / sound as in 'beef', although it can be adapted to any pair of sounds which hearing aids users especially students have differentiation problems with (British Council, 2019).

Any individual with sound discrimination problem may have difficulty telling the difference between words such as "sister" and "sitter" or "cat" and "cot." Overall, the person cannot distinguish between the slight differences in the sounds of words. This problem can sometimes make it hard for them to understand what people are saying. This is exacerbated in noisy environments such as classrooms or even at home if they belong to a large family or have loud music and television (Petex, 2018). Sound and word discrimination plays an essential role in both language and reading development. To achieve literacy, children must have phonemic awareness; difficulties with auditory discrimination can challenge young readers. People with reduced hearing levels are not the only ones who can struggle with auditory attention. Ability to attend can be affected by multiple factors, such as amount of sleep, nutrition, bodily comfort, emotional state, motivation, and interest in the topic, to name a few.

According to Willacy (2018), there may be little or no symptoms associated with the cause of perforation in auditory attention. Possible symptoms include changes in how a child (male and female) hears, that may range from slightly muffled to significant loss, noises in a child's ear - buzzing or ringing (tinnitus), aching or pain in a child's ear, itching in a child's ear, fluid leaking from the ear, and a high temperature (Willacy, 2018). If the perforated eardrum is caused by a middle ear infection, one may have earache which suddenly gets worse when the drum perforates but then quickly gets better.

6. Research Methodology

This research study made use of survey research design. Calabar Municipal local Government Area of Cross River State is the area of the study. The Population of this study is drawn from the One Thousand, two hundred and three (1,203) people living in Calabar Municipal Local Government Area

of Cross River State. 120 sample size was drawn as sample size for this study. The selection was done through the Accidental sampling technique. The instrument was used for collection of data was the questionnaire. The experts certified that, the instrument was face and content valid and could then

be used for the study. The reliability of the instrument for this study is obtain through the Cronbach Alpha reliability method. The researchers visited the council or area selected for the study and administered the questionnaire with the aid of two research assistants.

7. Presentation of result

This section deals with the analysis of the four research questions directing the study. The data are presented in Tables using simple percentage.

Research Question One: What is the level of sound detection among hearing aids users in Calabar Municipal?

To answer this research question, responses to items 1-5 of section B on the questionnaire were analyzed. The result of the analysis is presented in Table 1.

Table 1: Response of the respondents on the level of sound detection among hearing aids users in Calabar Municipal

	Sound detection	Mean	SD	Remark
1	Sound detection is the discrimination of sound from background noise	3.2400	.65652	Significant
2	Detection is the most basic of listening tasks among hearing aids users	3.8600	.49528	Significant
3	Detection of sound begins in the third trimester of pregnancy and continues to develop during the first year of life	3.1400	.72871	Significant
4	Hearing aids work by amplifying sound through a three-part system	3.6200	.60238	Significant
5	Sound travels from its source to the outer ears of a listener	3.5400	.61312	Significant

Source: Field 2023

Table 1 presents the mean ratings of the level of sound detection among hearing aids users. All the isolated items recorded mean rating ranging from 3.14 to 3.86 which were above the cut-off mark of 2.50, thus, indicating that the level of sound detection among hearing aids users in Calabar Municipal is positive. The standard deviation ranged from 0.49 to 0.73 which revealed that respondents were not too far from the mean and each other in their responses.

Research Question Two: What is the level of sound localization among hearing aids users in Calabar Municipal? To answer this research question, responses to items 6-10 of section B on the questionnaire were analyzed. The result of the analysis is presented in Table 2.

Table 2: Response of the respondents on the level of sound localization among hearing aids users in Calabar Municipal

	Sound localization	Mean	SD	Remark
6	Sound localization is a listener's ability to identify the location or origin of a detected <u>sound</u> in direction and distance	3.3200	.58693	Significant
7	Sound localization is the ability to locate the source of a sound	3.9200	.27405	Significant
8	Sound localization is important during class discussions and conversations with multiple people	3.2000	.67006	Significant
9	Under difficult listening conditions, or for a hearing-impaired person, localization can play a vital part in understanding group conversations	3.7000	.46291	Significant
10	Impaired localization probably plays a more significant role in speech communication difficulties than is usually appreciated	3.6000	.49487	Significant

Source: Field 2023

Table 2 presents the mean ratings of the level of sound localization among hearing aids users in Calabar Municipal. All the isolated items recorded mean rating ranging from 3.20 to 3.92 which were above the cut-off mark of 2.50, thus, indicating that the level of sound localization among hearing aids users in Calabar Municipal is positive. The standard deviation ranged from 0.27 to 0.67 which revealed that respondents were not too far from the mean and each other in their responses.

Research Question Three: What is the auditory attention level among hearing aids users in Calabar Municipal? To answer this research question, responses to items 11-15 of section B on the questionnaire were analyzed. The result of the analysis is presented in Table 3.

Table 3: Response of the respondents on the auditory attention level among hearing aids users in Calabar Municipal

	Auditory attention	Mean	SD	Remark
11	Attention is a multimodal process, essential for development and learning and the acquisition of language	3.3200	.58693	Significant
12	The auditory attention is a cognitive process that allows the listener to focus selectively on the stimulus of interest	3.9400	.23990	Significant
13	The auditory attention of students can be influenced by hearing impairment, causing impairment in attention and comprehension skills	3.2400	.68690	Significant
14	Auditory Attention is often discussed as a figure-ground task	3.7000	.46291	Significant
15	Auditory attention is just one way of attending to an activity – but it may be the most important part of attention at school.	3.6200	.49031	Significant

Source: Field 2023.

Table 3 presents the mean ratings of the auditory attention level among hearing aids users in Calabar Municipal. All the isolated items recorded mean rating ranging from 3.24 to 3.94 which were above the cut-off mark of 2.50, thus, indicating that the auditory attention level among hearing aids users in Calabar Municipal is positive. The standard deviation ranged from 0.24 to 0.69 which revealed that respondents were not too far from the mean and each other in their responses.

Research Question Four: What is the level of sound discrimination among hearing aids users in Calabar Municipal? To answer this research question, responses to items 1-25 of section B on the questionnaire were analyzed. The result of the analysis is presented in Table 4.

Table 4: Response of the respondents on the level of sound discrimination among hearing aids users in Calabar Municipal

	Self-concept formation	Mean	SD	Remark
16	Sound discrimination is the ability to recognize similarities and differences between sounds	3.2800	.57286	Significant
17	Sound discrimination allows people to distinguish between phonemes in words	3.9000	.30305	Significant
18	Sound discrimination allows someone to tell the difference between words and sounds that are similar and words and sounds that are different	3.1800	.66055	Significant
19	Sound discrimination is very important to early readers and writers	3.6600	.47852	Significant
20	Sound and word discrimination plays an essential role in both language and reading development.	3.5800	.49857	Significant

Source: Field 2023

Table 4 presents the mean ratings of the level of sound discrimination among hearing aids users in Calabar Municipal. All the isolated items recorded mean rating ranging from 3.28 to 3.90 which were above the cut-off mark of 2.50, thus, indicating that the level of sound discrimination among hearing aids users in Calabar Municipal is positive. The standard deviation ranged from 0.30 to 0.66 which revealed that respondents were not too far from the mean and each other in their responses.

8. Discussion of findings

The result of the first research questions revealed that the level of sound detection among hearing aids users in Calabar Municipal is significantly high. The findings of this study is in line with the view of Brungart et al (2001) who observed that sound

detection is the discrimination of sound from background noise, either by ear or by electronic instrument. Detection is the most basic of listening tasks, as it requires the listener to determine the presence or absence of sound, or of a particular sound. Werner (2007) who also stated that, a student’s audiologist should ensure that the device settings allow the student access to the full range of speech sounds accessible to the student, these settings can become less effective over time. The perception of sound level is fundamental to hearing our environment and in treating hearing impairment, from restoring dynamic range to achieving comfortable levels of gain in a hearing aid. The ability to discriminate the levels of different sounds is vital to our perception of the environment as well as communication. Bentler (2000) who also stated that, spatial hearing permits a listener to identify the locations of sound sources and

it aids in detection and recognition of sounds in the presence of other competing sounds. Hearing aids work by amplifying sound through a three-part system. The microphone receives sound and converts it into a digital signal. The amplifier increases the strength of the digital signal. The speaker produces the amplified sound into the ear. A hearing aid is a device designed to improve hearing by making sound audible to a person with hearing loss. Hearing aids are classified as medical devices in most countries, and regulated by the respective regulations.

The result of the second research questions revealed that the level of sound localization among hearing aids users in Calabar Municipal is significantly high. The findings of this study is in agreement with the view of Thompson et al. (2005) who observed that, sound localization is a listener's ability to identify the location or origin of a detected sound in direction and distance. The sound localization mechanisms of the mammalian auditory system have been extensively studied. The auditory system uses several cues for sound source localization, including time difference and level difference (or intensity difference) between the ears, and spectral information. These cues are also used by other animals, such as birds and reptiles, but there may be differences in usage, and there are also localization cues which are absent in the human auditory system, such as the effects of ear movements. Animals with the ability to localize sound have a clear evolutionary advantage. Sound localization, the ability to locate the source of a sound, begins to develop within the first seven months of life and continues to improve as the child has more experience with hearing and listening. When localizing a sound, the brain compares the relative loudness of the sound at each ear. Sounds that originate from the right or left side of a person are easier to locate than sounds originating from in front or behind. Individuals with unilateral or imbalanced hearing loss (including imbalanced hearing levels with hearing devices) may have more difficulty locating the source of a sound.

The result of the third research questions revealed that the auditory attention level among hearing aids users in Calabar Municipal is significantly low. The findings of this study is in line with Sauer, (2006) who reported that individual with learning difficulties, have poorer performance on alertness, suggesting delayed maturation of auditory processing skills. Attention is a multimodal process, essential for development and learning and the acquisition of language, not only on aspects relating to the field of linguistic structures, but also in the development of communication skills that allow the hearing aids users to participate in a conversation, talk about a topic or tell a story. The

auditory attention is a cognitive process that allows the listener to focus selectively on the stimulus of interest, a stimulus while ignoring irrelevant competing, so the listener consciously selects the stimulus which he will watch and process its response. Medwetsky (2002) who also noted that, the auditory attention of students can be influenced by hearing impairment, causing impairment in attention and comprehension skills and thus compromising the performance and learning of these children.

The result of the fourth research questions revealed that that the level of sound discrimination among hearing aids users in Calabar Municipal is significantly high. The findings of this study is in agreement with the view of Kung (2005) who observed that, sound discrimination is the ability to recognize similarities and differences between sounds. Mainly, sound discrimination allows people to distinguish between phonemes in words. Phonemes are the smallest units of sound in any given language. Sound discrimination allows someone to tell the difference between words and sounds that are similar and words and sounds that are different. British Council (2019) who also noted that, sound discrimination is very important to early readers and writers, because when a child wants to write the words "pig" or "bat," it will be very important to be able to identify all of the sounds in those words. Otherwise, reading and writing small words like these will be impossible without memorizing every what every single word looks like, right down to the last letter. Imagine trying to write long words such as "encyclopedia" without being able to separate that word into syllables in your head as you write it down!

9. Conclusion / Recommendations

Based on the of findings of this study, it was concluded that the level of sound detection, sound localization, auditory attention and sound discrimination among hearing aids users in Calabar Municipal are positive. Based on the findings of the study was recommended that student's audiologist should ensure that the device settings allow the student access to the full range of speech sounds accessible to the student, these settings can become less effective over time.

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