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Auditory Perception and Comprehensibility Among Selected Hard of Hearing English as Second Language Speakers in Kano State, Nigeria

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Abstract

Every oral communication is dependent on information being correctly perceived or received and understood. However, the problem of auditory perception and comprehensibility among hearing impaired people is to identify the abnormality of hearing loss at a specific anatomic level of the auditory system which determines comprehensibility. Using audiological instrument such as otoscope, audiometer and tympanometer, this study examines auditory perception and comprehensibility among hearing impaired people. The theoretical framework adopted for this study is Trace Model of speech perception and the research sample consists of sixty-six (66) patients of hearing impaired at the unit of Ear, Nose and Throat (ENT), Aminu Kano Teaching Hospital (AKTH), Kano State, Nigeria through purposeful and random sampling techniques. The data were collected using hearing test with the aid of speech audiometry. The test has words and was presented via headphones which the participants listen to and repeated. The data were analysed qualitatively. The finding of this study shows that ESL hearing impaired listeners utilise auditory feedback from their own speech to shape, adjust, or define phonetic categories in the second language for comprehensibility while accurate phonetic categories lead to improved perceptual ability irrespective of their degree or level of hearing. The study, therefore, concludes that ESL hearing-impaired people find it difficult to realize L2 sounds (especially diphthongs) which compound the inability to recognize words and comprehend speeches. Hence, there is need for effective audition or amplification.

Keywords: Auditory, Perception, Comprehensibility, Hearing impaired, Trace Mode.

Introduction

Every oral communication is dependent on information being correctly received and understood. In many situations in today's society, language users are exposed to a variety of sounds which make comprehension and sound realization more difficult. Listening involves decoding auditory input by matching it with representations stored in long term memory and subsequent encoding into working memory. When auditory input is distorted by noise and/or a hearing loss, the process does not happen as smoothly – fragmented information must be stored in working memory (Rudner and Lunner, 2013). Auditory communication requires listeners to select relevant information using attention and effort, and then comprehend the information before storing it into memory (Kalluri and Humes, 2012). If the acoustic signal is limited or distorted because of a hearing impairment, there will surely be problem with the realization of diphthongs as well as speech comprehension. The mechanism behind this is not only related to limited and distorted auditory information, but also to a decline in cognitive functioning. Central auditory functions are complex and not known in detail. As a result, there is no single measurement available which completely describes these functions. Nevertheless, different kinds of tests, ranging from electrophysiological measurements (Larsby et al, 2000) to behavioral measurement of cognitive abilities, can give different aspects and angles of approach and together contribute to the understanding of these functions (Musiek, 1999).

Previous studies have shown that speech understanding in noise is affected by the characteristics of the background noise (Bronkhorst & Plomp, 1992; Gustafsson & Arlinger, 1994; Bacon et al, 1998) as well as by peripheral hearing (e.g. Festen & Plomp, 1990; Hygge et al, 1992) and cognitive ability (Gatehouse et al., 2003; Lunner, 2003).When the signal-to-noise ratio becomes unfavorable and the processing goes from being easy and automatic to being difficult and cognitively demanding, the degree of perceived effort is likely to increase (Pichora-Fuller et al, 1995).

However, the problem of auditory perception and comprehensibility among hearing impaired people is to identify the abnormality of hearing loss at a specific anatomic level of the auditory system which determines comprehensibility. It is on this basis that this study examines auditory perception and comprehensibility among hearing impaired people.

Literature Review

The process of successful listening comprehension is highly automatized in proficient listeners as little or no conscious attention is required (Brunfaut & Revesz, 2015). Hearing impaired adults make several efforts in listening to comprehend speeches. L2 listeners commonly lack harmonious top-down and bottom-up processing (Yeldham, 2016) and therefore may experience difficulties with their auditory skills and listening comprehension abilities. It has been verified that some cognitive functions deteriorate as a result of hearing impairment. More precisely, it has been proven that the phonological ability decline when auditory stimulation is reduced during a longer period (Andersson & Lyxell, 2007; Andersson, 2001) for severely hearing-impaired and deafened adults. The extra problems with speech comprehension in the adult population, especially in noisy situations, are often discussed in connection with a poorer peripheral hearing. In both natural and structured activities, auditory skills are essential to integrate, interpret and comprehend auditory or linguistic information which are interrelated and overlapping (Cole & Flexer, 2015). Comprehension of a spoken message during communication interaction occurs when listeners can infer what is said, based on their linguistic background and contextual knowledge (Chang, Wu & Pang, 2013).

However, the complexity of the Second Language Acquisition (SLA) process is evident and there are many influencing variables that need to be considered. Listening comprehension is a key component of language acquisition that has only recently been investigated (Vandergrift & Baker, 2015). When a learner actively listens, the rules of that language are internalized and the emergence of other language skills is facilitated such as L2 vocabulary and discourse skills (Vandergrift, 2011). Listening is an interactive, cognitive process which involves neurological, linguistic, semantic, and pragmatic processing (Rost, 2011). These processes concurrently involve drawing on resources such as linguistic knowledge, world knowledge, and knowledge about the communicative context (Rost, 2011).

Yeldham (2016) suggests that listening difficulties experienced by ESL learners may be cognitive in nature. These results in the inability to recognize the words of L2, concentrate and keep up with the speaker, and to construct and recall meaning (Yeldham, 2016). These difficulties are experienced by adults with or without hearing impaired ESL learners which further impacts their auditory skills negatively. In fact, the hard-of hearers even find it difficult to realize L2 sounds (especially diphthongs) which compound the inability to recognize words and comprehend the speeches.

Poor listening can result in poor SLA while poor SLA can be caused by poor listening abilities.

Research has also shown that certain environmental factors such as classroom noise may affect learner's attention and speech perception, thereby negatively influencing their auditory skills and listening comprehension (Nelson, Kohnert, Sabur & Shaw, 2005). Many hearing-impaired individuals report feeling fatigue at the end of the day. These individuals are forced to exert more cognitive effort throughout the day as they strain to understand speech in an ever-changing auditory environment through an impaired/degraded auditory system (Rabbitt, 1991). Changes in the peripheral auditory system impact higher level cortical speech processing networks as well, causing speech understanding to decline even in older adults with only mild to moderate hearing loss (Peelle, Troiani, Grossman, & Wingfield, 2011). Sensory declines in the auditory system in turn increase listening effort. With this perceptual decline in hearing, hearing impaired individuals are forced to allocate and expend more cognitive resources to understand speech. The neural activity required to re-allocate these cognitive resources to the auditory system is related to the demand of the task at hand and cognitive ability (Peellee al, 2011). By expending more cognitive effort to maintain listening performance, hearing impaired individuals become fatigued at the end of the day (Downs, 1982).

Meanwhile, there is need to separate auditory objects such as speech, voices, music, and environmental noises from the auditory background and organised with coherent representation. To achieve this, the central auditory processing is required considering the nature and/or degree of hearing impairment. Mild cognitive impairment (MCI) and Alzheimer's disease (AD) according to Idrizbegovic et al. (2011) and Gates et al. (2011) have been associated with decreased performance on tests of central auditory performance such as speech in noise.

Theoretical Framework

The theoretical framework of this study is Trace Model of speech perception founded by McClelland and Elman (1986). This model is an interactive-activation one in which information processing occurs through excitatory and inhibitory interactions among a large number of simple processing units meant to represent the functional properties of neurons or neural networks. This framework is an interactive-activation approach which shows that information processing takes place through the excitatory and inhibitory interactions among a large number of processing elements called units (McClelland & Rumelhart. 1981; Rumelhart & McClelland. 1981, 1982).

Trace model is one of the earliest models developed for perceiving speech which takes the various sources of information found in speech and integrate them to identify single words. It is also a connectionist network with an input layer and three processing layers: pseudospectra (feature), phoneme and word. These components of a speech have their own role in creating intelligible speech, and using Trace Model to unite those components leads to a complete stream of speech, instead of individual components. This approach grew out of a number of earlier ideas. Some coming first from research on spoken language recognition (Marslen-Wilson & Welsh, 1978; Reddy. 1976) and others arising from more general considerations of interactive parallel processing (Anderson. 1977; Gross-berg. 1978; McClelland. 1979).

An important assumption of this model is that activation of higher-order units activates their lower-order units. For instance, activation of a word containing a /p/ phoneme would activate the phoneme. Therefore, the model predicts that top-down sources at a higher level can also influence performance in addition to the influence of bottom-up sources. These two properties of the model agree with the outcomes of several lines of research (Massaro, 1987; McClelland and Elman, 1986). This study, therefore, uses the assumption of Trace model of speech perception and takes the perceptual results reported a further step to predict L2 auditory perception and comprehensibility among the ESL hard-of-hearers.

Population of the Study

The population of this study comprised male and female respondents who are hearing impaired adult second language learners of English, and are patients at the Department of Otolaryngology (Ear, Nose and Throat – ENT), Aminu Kano Teaching Hospital (AKTH). Ten (10) patients/subjects were recorded on each of the eight (8) clinical days by the research assistants who are audiologists and staff of the department. This implies that a total number of eighty (80) patients was recorded from eight (8) of the clinical days and sixty-six (66) was sampled out. The subjects of this study were hearing impaired persons with different qualifications above Senior Secondary Certificate of Education (SSCE). Out of this number, 27 (representing 41%) had conductive and sensorineural hearing loss while the remaining 12 (18%) had mixed hearing loss. Similarly, 32 out of the 66 people studied (representing 48%) suffered from mild hearing impairment while 17 persons (representing 26%) suffered from moderate to severe hearing impairments.

Test Materials and Procedure

The study was conducted in an audiology room meant for Pure Tone Audiometry (PTA) and speech audiometry at AKTH. The hearing test has thirty-five (35) spondaic words from the Central Institute for the Deaf (CID) auditory wordlist. These words are made up of bisyllables, typically nouns with equal stress placed on each syllable such as ‘playground’ /pleigraund/. Some of the words numbered 22 contain one or two diphthongs while the remaining 13 have monophthongs. A monophthong contains one vowel sound in a syllable and a diphthong has a combination of two vowel sounds in a syllable. The test was conducted by expert audiologists using high standard equipment like audiometer and tympanometry and a prefabricated sound booth.

Confidentiality and Ethical consideration

Before deploying data collection instrument, participants were given consent form to read carefully and sign. Anonymity and confidentiality of the participants were ensured since there will be no inclusion of any identifiers and or any incriminating information on participants. Similarly, an approval was granted for ethical clearance/approval from the Health Research and Ethics Committee, Aminu Kano Teaching Hospital (AKTH), Kano and approval to conduct the research from office of the Chief Medical Director (CMD) through office of the Chief Medical Advisory Committee (CMAC) and later Head, Department of Ear, Nose and Throat (ENT).

Data Presentation and Analysis

This section presents and analyses the data obtained from the participant’s audiometric evaluation form which was used by the researcher and the audiologists at AKTH to assess the hearing threshold of the participants in decibel. Prior to the commencement of the speech audiometry, a Pure Tone Audiometry (PTA), which is the basic test to find out if a hearing lost is present or not, was conducted on the subjects. During the test, the test person wore a headphone through which pure tones at different frequencies were presented on a computer screen. The intensity of the tones was gradually reduced until the hearing threshold (the point at which tones were barely audible) was found. The result was expressed in decibel (dB) and entered into an audiogram form (i.e. Audiology Assessment Form) which is presented in Table 1.

Table 1: Pure Tone Audiometry Test Results

S/N	AUDIO NUMBER	RIGHT EAR	LEFT EAR
01	001	53.3dB	56.6dB
02	002	63.3dB	61.6dB
03	003	27.5dB	26dB
04	004	51.6dB	50dB
05	005	76.6dB	71.6dB
06	006	58dB	120dB
07	007	27.5dB	26dB
08	008	26dB	26.5dB
09	009	35dB	48.3dB
10	110	26dB	26dB
11	011	113dB	113dB
12	012	30dB	31dB
13	013	26dB	26.2dB
14	014	53.7dB	66.25dB
15	015	43.3dB	65dB
16	016	105dB	76.6dB
17	017	46.2dB	53.3dB
18	018	27dB	26.3dB
19	019	46.6dB	51.6dB
20	021	28.3dB	26dB
21	021	75dB	65dB
22	022	27.6dB	35dB
23	023	110dB	108.3dB
24	024	27.5dB	26.7dB
25	025	28dB	28.3dB
26	026	26dB	26.6dB
27	027	28.3dB	106.6dB
28	028	27dB	41.6dB

29	029	95dB	100dB
30	030	55dB	26.6dB
31	031	28dB	113.3dB
32	032	27dB	26dB
33	033	29.3dB	101.6dB
34	034	110dB	110dB
35	035	58.75dB	56.25dB
36	036	61.6dB	120dB
37	037	120dB	76.6dB
38	038	36.25	48.3dB
39	039	28.3dB	26.6dB
40	040	26dB	26.6dB
41	041	28.3dB	30dB
42	042	53.3dB	56.6dB
43	043	45.6dB	48.3dB
44	044	27dB	113.3dB
45	045	27dB	26dB
46	047	28.3dB	26.3dB
47	048	30dB	30dB
48	049	30dB	30dB
49	50	115dB	31.6dB
50	052	83.3dB	96.6dB
51	053	33dB	35dB
52	054	40dB	40dB
53	055	55dB	41.6dB
54	056	31.6dB	35dB
55	057	30dB	30dB
56	058	30dB	30dB
57	060	31.6dB	30dB
58	061	53dB	66dB
59	062	35dB	120dB
60	063	113.75dB	27.5dB
61	064	31.6dB	31.6dB
62	065	67.5dB	61.25dB
63	067	27.5dB	26dB
64	068	51.25dB	32.5dB
65	069	31.25dB	33.3dB
66	070	38.3dB	43.3dB

Table 1 shows the results of the degree of the impairment. All the participants in this study are suffering from one form of hearing impairment or another. Normal hearing is characterised by a threshold of 25 dB HL or less while hearing impairment is denoted by a threshold of 26 dB HL or greater. Standard clinical hearing assessment in adults and older children is mainly based on pure-tone audiometry where the detection threshold for simple tones is determined at several frequencies relevant for human hearing. By measuring the air and bone conduction thresholds, the type and the degree of hearing loss can be determined, and often the underlying cause as well. Also, when rehabilitating a hearing loss by means of a hearing aid, the audiogram provides direct input for the hearing aid selection and its first fit. Pure-tone threshold audiometry thus has a very high clinical value and is used worldwide as the main clinical hearing test.

Results of the Speech Audiometry Test

A test on speech audiometry which is a tool in assessing hearing loss was also conducted on the subjects. It aids in determining the degree and type of hearing loss in conjunction with PTA. This type of test shows how well a person listens to and repeats words. The test has spondaic words and was presented via headphones which the participants listen to and repeat. The researcher watched the subjects very closely as they listened and repeated the spondee words. At the end of the test, a percentage of how many words are correctly perceived and repeated was derived and presented in Table 2.

Table 2: Speech Audiometry Test Results

S/N	Word	Transcription (TR)	Participants Realization (PR)	Correct (TR and PR)	Incorrect (TR and PR)	Total
1	Airplane	/eəplein/	/eplen/	29 (44%)	37 (56%)	66 (100%)
2	Armchair	/ɑ:mʧeə/	/amʧe/	25 (38%)	41 (62%)	66 (100%)
3	Baseball	/beizbɔ:l/	/bezbɔl/	21 (32%)	45 (68%)	66 (100%)
4	Birthday	/bɜ:Ɵdei/	/bɜzde/, /bɜtde/	32 (49%)	34 (51%)	66 (100%)
5	Cowboy	/kɑʊbɔi/	/kɑʊbɔi/	66 (100%)	0 (0%)	66 (100%)
6	Daybreak	/deibreik/	/debrek/	19 (29%)	47 (71%)	66 (100%)
7	Eardrum	/iədr^m/	/ədrɔm/	23 (35%)	43 (65%)	66 (100%)
8	Farewell	/feəwel/	/fewel/	40 (61%)	26 (39%)	66 (100%)
9	Greyhound	/greihɑʊnd/	/grehɑʊnd/	27 (41%)	39 (59%)	66 (100%)
10	Hardware	/hɑ:dweə/	/hɑdwe/	24 (36%)	42 (64%)	66 (100%)
11	Headlight	/hedlɑit/	/hedlɑit/	66 (100%)	0 (0%)	66 (100%)
12	Hothouse	/hɔthɑʊs/	/hɔthɑʊs/	66 (100%)	0 (0%)	66 (100%)
13	Iceberg	/ɑisbɜ:g/	/ɑisbɜg/	20 (30%)	46 (70%)	66 (100%)
14	Mousetrap	/mɑʊstræp/	/mɑʊstrap/	34 (52%)	32 (48%)	66 (100%)
15	Oatmeal	/əʊtmi:l/	/ɑʊtmil/	22 (33%)	44 (67%)	66 (100%)
16	Pancake	/pænkeik/	/pankek/	19 (29%)	47 (71%)	66 (100%)
17	Playground	/pleigrɑʊnd/	/plegrɑʊnd/	42 (64%)	24 (36%)	66 (100%)
18	Railroad	/reilrəʊd/	/relrɑʊd/	32 (48%)	34 (52%)	66 (100%)
19	Schoolboy	/skʊ:lbɔi/	/skʊlbɔi/	58 (88%)	08 (12%)	66 (100%)
20	Sidewalk	/sɑidwɔ:k/	/sɑidwɔk/	50 (76%)	16 (24%)	66 (100%)
21	Stairway	/steəwei/	/stewe/	17 (26%)	49 (74%)	66 (100%)
22	Whitewash	/wɑitwɔʃ/	/wɑitwɔʃ/	66 (100%)	0 (0%)	66 (100%)

Table 2 shows that the speech audiometry (hearing test) for diphthongs has twenty-two (22) spondaic words from the Central Institute for the Deaf (CID) auditory wordlist. These words are made up of bisyllables, typically nouns with equal stress placed on each syllable. Most of these words have one or two diphthongs while the remaining few have monophthongs only. Some of the words have greater percentage of realisation than others such as 'headlight' /hedlɑit/, 'cowboy' /kɑʊbɔi/, 'hothouse' /hɔthɑʊs/ and 'whitewash' /wɑitwɔʃ/ while others have less percentage when compared to others such as 'daybreak' /deibreik/, 'stairway' /steəwei/ and 'greyhound' /greihɑʊnd/.

Discussion

Based on the analyzed results, one can infer that individuals who present some degree of hearing loss will dispense higher listening effort during the accomplishment of the pure tone audiometry and speech audiometry tests respectively. This is due to the audibility reduction which could be as a result of the injury of the peripheral and/or central auditory system. There is, however, uncertainty in the speech signal which enables listeners to infer a 59target production that is closer to the mean of a phonetic category than the speech sound they actually heard. An L2 sound that is similar (such as /ai/ and /au/), but not identical to an L1 speech sound may enjoy an advantage in early stages of L2 acquisition. This is because the simple substitution of the L1 sound for its counterpart in the L2 might result in a high degree of intelligibility. Flege (1987, 1995) suggested that L2 learners' relative degree of accuracy in producing L2 speech sounds will vary over time as a function of their perceived relation to sounds in the L1 inventory.

Assuming a language has multiple phonetic categories, listeners who are hearing-impaired must first infer which category produced a speech sound and can then use that information to guide their inference of acoustic detail. A basic assumption in the model is that the hearing-impaired have knowledge of phonetic categories but are trying to infer phonetic detail. This assumption contrasts with previous models but is consistent with empirical data showing that listeners are sensitive to sub-phonemic detail at both neural and behavioral levels (Pisoni & Tash, 1974; Blumstein, Myers, & Rissman, 2005). Phonetic detail provides coarticulatory information that can help listeners identify upcoming words, and data have suggested that listeners use this coarticulatory information on-line in lexical recognition tasks (Gow, 2001). Though one could contend that listeners' ultimate goal is to categorize speech sounds into discrete phonemes, they seem to attend to phonetic detail in the speech signal as well. Thus, an L2 sound that is more dissimilar phonetically from the closest L1 sound (such as /ei/, /ɔi/, /əu/, /iə/, /ɛə/, /uə/), on the other hand, is expected to show a disadvantage in early and later stages of L2 learning. Several different L1 speech sounds might be used as substitutes for it; and the learner may struggle to find new articulatory patterns for producing it. Some scholars (e.g. Yamada et al., 1994; Llisterri, 1995) generally agreed that the relationship between production and perception is complex and is affected by factors such as amount of L2 experience.

Meanwhile, a number of investigators have suggested that L2 acquisition recapitulates L1 acquisition in the sense that perceptual development tends to ‘‘lead’’ development in segmental production (Flege, 1995; Rochet, 1995). The finding might be taken as support for an alternative hypothesis, namely that L2 segmental production leads L2 segmental perception (e.g., Goto, 1971; Sheldon & Strange, 1982; Yamada et al., 1994). The results of the present study showed that the participants used their phonetic as well as their phonological perception. In particular, phonetic perception was evident in the participants' perceptual patterns of the English diphthongs, which were produced by hearing impaired Hausa native speakers of English. Although they assimilated two Hausa diphthongs (i.e. /ɑi/ /ɑʊ/), they were able to detect the phonetic differences between English vowels particularly, the diphthongs. The detected phonetic differences are, in this case, phonologically relevant in L2 as they distinguish L2 phonological vowel categories (such as Cowb<u>oy</u>' /kɑʊb<u>ɔɪ</u>/ and R<u>ai</u>lroad' /r<u>ei</u>lrəʊd/).

The pure tone audiometry and speech audiometry test results of this study indicate that production can inform perception in a second language in the sense that enhanced knowledge of production leads to enhanced perceptual ability. To support this, Callan, Jones, Callan, and Akahane-Yamada (2004) found that activation of motor cortices was even greater among nonnative speakers when at-tempting to perceptually identify phonetic contrasts that were ambiguous. Native speakers by contrast, exhibit greater activation only in auditory cortices in the same situation. Therefore, ESL hearing impaired listeners utilise auditory feedback from their own speech to shape, adjust, or define phonetic categories in the second language for comprehensibility while accurate phonetic categories lead to improved perceptual ability irrespective of their degree or level of hearing.

Conclusion

The Trace Model of speech perception phonetic identifies boundaries between perceptually assimilated second language sounds. The ESL hearing-impaired people find it difficult to realize L2 sounds (especially diphthongs) which compound the inability to recognize words and comprehend speeches. Impairment in hearing, therefore, can result in poor SLA while poor SLA can be caused by poor listening abilities. In clinical contexts, speech comprehension is typically measured by the application of speech perception tests (such as the pure tone audiometry and speech audiometry) which entails identifying the words correctly realized in a silent or noisy listening condition.

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