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ASSESSMENT OF THE CLINICAL UTILITY OF THE SENTENCE IDENTIFICATION TEST IN KANNADA FOR ADULTS

Contributions:
A Study design/planning
B Data collection/entry
C Data analysis/statistics
D Data interpretation
E Preparation of manuscript
F Literature analysis/search
G Funds collection

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Abstract

Introduction: A sentence identification test was developed by Geetha, Kumar, Manjula, and Pavan (2014) in the Kannada language. The test consists of 25 equivalent sentence lists with 10 sentences each. The present study aimed to assess the clinical utility of this test.

Material and methods: All sentences were presented to 5 groups of adults with 10 individuals in each group. Four groups, each of 10 individuals, had hearing loss: mild, moderate, moderately-severe, or severe. The fifth group had 40 individuals with normal hearing sensitivity. Standardized lists of 25 sentences were presented monaurally at the most comfortable level in a sound-treated double room. The number of correctly identified words was tabulated.

Results: The mean identification scores decreased with increase in the degree of hearing loss, although the scores were comparable between the normal and mild group. A comparison of scores between each list within each group revealed that there was no significant difference between the lists for the scores obtained from the individuals with mild, moderate, moderately-severe, and severe degrees of hearing loss.

Conclusions: The developed sentence material is sensitive to differences in speech identification ability across different degrees of hearing loss. In addition, the mean number of correctly identified words do not vary across the lists in any of the four groups, suggesting equivalency across the standardized 25 lists in the clinical groups.

Key words: clinical utility • hearing loss • Kannada • list equivalency

OCENA UŻYTECZNOŚCI KLINICZNEJ TESTU IDENTYFIKACJI ZDAŃ W JĘZYKU KANNADA DLA OSÓB DOROSŁYCH

Streszczenie

Wprowadzenie: Test identyfikacji zdań w jezyku kannada został opracowany przez Geetha, Kumar, Manjula i Pavan (2014). Test składa się z 25 równoważnych list, z których każda zawiera 10 zdań. Celem obecnego badania była ocena użyteczności klinicznej testu.

Materiał i metody: Wszystkie zdania były prezentowane 5 grupom. W składzie czterech 10-osobowych grup znalazły się osoby z niedosłuchem odpowiednio: lekkim, umiarkowanym, umiarkowanie ciężkim i ciężkim. W piątej grupie było 40 osób z normalną czułością słuchu. Standaryzowane listy po 25 zdań prezentowano do jednego ucha na poziomie komfortowego słyszenia w pomieszczeniu dźwiękoszczelnym. Liczbę prawidłowo zidentyfikowanych słów zapisywano w tabeli.

Wyniki: Średni wynik identyfikacji zmniejszał się wraz ze wzrostem poziomu ubytku słuchu, chociaż wyniki dla grupy z normalnym słuchem i z niedosłuchem lekkiego stopnia były porównywalne. Porównanie wyników poszczególnych list wewnątrz każdej grupy wykazało, że nie było istotnych różnic między listami w odniesieniu do wyników uzyskanych przez osoby z lekkim, umiarkowanym, umiarkowanie ciężkim i ciężkim niedosłuchem.

Wnioski: Opracowany materiał zdaniowy jest wrażliwy na różnice zdolności identyfikacji mowy osób z różnymi poziomami niedosłuchu. Ponadto średnia liczba poprawnie zidentyfikowanych słów jest podobna dla różnych list w każdej z czterech grup, co sugeruje, że wszystkie (25) standaryzowane listy są równoważne dla grup klinicznych.

Słowa kluczowe: użyteczność kliniczna • niedosłuch • język kannada • równoważność list

Introduction

Speech is a sophisticated form of human communication. Measurement of speech perception provides useful information in assessing communication difficulties experienced by listeners with hearing loss. The scope of speech perception tests extends to rehabilitation, where it is used for the assessment of an individual's speech perception ability before and after the fitting of hearing aids or cochlear implants [1]. Furthermore, it helps in choosing appropriate amplification and is used for counseling [2,3].

While there are many tests for assessing speech perception involving meaningful words or nonsense syllables, the sentence type has the advantage of giving additional insight regarding the individual's performance in more realistic communication scenarios. They are considered to be valid indicators of intelligibility and are a better representation of verbal communication [4]. It is expected that sentence test material will elicit better accuracy and effectiveness in measuring speech reception thresholds because sentence materials provide much steeper intelligibility functions in contrast to tests involving single words [5]. The capacity to manipulate certain patterns like intonation and co-articulation effects in ongoing speech is severely limited when using single words, especially monosyllables [6]. Miller, Heise, and Lichten noted that sentences have face validity as 'natural' and 'meaningful' stimuli for assessing auditory function [7].

There are a number of sentence tests in different languages: for example, the Central Institute of Deaf (CID) Everyday Sentences Test in English developed by Silverman and Hirsh [8]; a sentence test in Dutch by Plomp and Mimpen [9]; the hearing-in-noise test (HINT) in English by Nilsson, Sullivan, and Soli [10]; HINT in Danish [11]; HINT in Mandarin [12]; HINT in Cantonese [13]; and others.The need for developing tests in different languages arise as an individual's native language is an important factor in their speech perception [14]. Hence, administering speech tests in an individual's native language is considered ideal. India is a multilingual country with several languages. The All India Institute of Speech and Hearing is situated in Karnataka, a state in South India, where Kannada is the official language. The Institute renders clinical services to individuals with communication disorders. The majority of the service seekers visiting the Institute speak Kannada. This necessitates the development of a sentence test in Kannada for assessment of hearing and for fitting hearing devices.

A sentence test of 25 lists with 10 sentences in Kannada was developed in 2014 by Geetha et al. [15], in which a total of 700 commonly used sentences were selected from various sources. They were rated by 10 participants for naturalness of the sentences and predictability of the words in the sentences. Geetha et al. selected a total of 564 sentences based on familiarity and predictability ratings; the sentences were mixed with spectrally shaped noise at SNR levels from –7 dB to 0 dB in 1 dB steps. A pilot study was done to measure SNR-50. The participants repeated the words in 564 sentences at different SNRs, and at –5 dB SNR scores of approximately 50% were obtained. The most difficult and the easiest sentences were eliminated at this stage, resulting in 316 sentences.

Exactly 30 sentence lists with 10 sentences were formed after phonemically balancing the sentences within each list. The lists were presented to a group of 100 participants with normal hearing at –5 dB SNR at their most comfortable level. Statistical analysis comparing the SIS across different lists revealed that 5 lists were not equivalent to some of the other lists, and hence they were removed, leaving a test of 25 sentence lists.

Any speech material used to diagnostically assess a clinical population or for fitting hearing devices requires that it be validated in individuals having different degrees of hearing loss [16]. Hence, there is a need to present these sentences to the clinical population and test whether the sentences are sensitive enough to distinguish differences in perceptual ability across different degrees of hearing loss. Killion [17] has evaluated individuals with hearing impairment with the SIN test. The results revealed that individuals with mild hearing loss required higher SNR than normal individuals, even when the testing was done at higher intensity levels. In the current study, the normative level is considered to be –5 dB SNR, which, according to Killion, is well below the SNR required even for an individual with 40 dB hearing loss [17]. However, it has also been reported that hearing impaired individuals have poorer sentence recognition scores than their normal hearing counterparts, even if the test is presented in quiet [18]. Hence, in the present study, the sentences were presented without noise. For comparison purposes, a group of normal individuals were also tested in quiet.

Method

The study aimed to assess the clinical utility of the standardized sentence lists developed by Geetha et al. [15] in individuals with different degrees of hearing loss. Hence, different groups of individual with hearing loss were included in the study.

Participants

There were 40 individuals with (sensorineural) hearing loss in the age range 18 to 70 years (mean = 28.9 years) and 40 individuals with normal hearing aged from 22 to 55 years (mean = 28.9 years) who participated in the study. Hearing sensitivity was assessed by routine clinical audiometry. Normal hearing sensitivity was defined as air conduction pure tone thresholds within 15 dB HL across 250 to 8000 Hz and bone conduction thresholds within 15 dB HL across 250 to 4000 Hz. Further, the participants had 'A' type tympanograms and had ipsilateral and contralateral reflex thresholds at levels corresponding to normal hearing thresholds [19]. The categories of hearing loss consisted of mild, moderate, moderately-severe, and severe. Each category included 10 ears. The configuration of loss was restricted to flat type (<15 dB variation per octave in the threshold between 250 to 8000 Hz) and the speech identification scores had to be in agreement with the degree of hearing loss. None of the patients had any symptoms such as giddiness or vomiting sensation indicative of neural issues. The patients did not have any complaint or history of neurological or psychological problems. Normal middle ear status was confirmed by immittance evaluation. None of the individuals with hearing loss had prior experience with hearing aids.

Procedure

The participants were tested in a sound-treated room with noise levels complying with ANSI standards [20]. The sentence lists were presented monaurally at the participant's most comfortable level in quiet. The sentences were routed through a personal computer and delivered through Sennheiser HAD 200 closed dynamic headphones via a calibrated MA 53 diagnostic audiometer.

Participants practiced with 10 trial sentences and were provided with feedback regarding their performance before the start of the actual test runs. The participants were instructed to repeat the sentences as accurately as possible. They were also encouraged to guess the sentence if they were unsure of it and were given ample time to respond. The words correctly identified by the subjects were marked on a printed response sheet by the examiner. Each sentence was scored based on the number of key words (25% for each key word) correctly repeated (contractions, spelled out contractions, identifiable mispronounced words, and changes in plurality were counted as correct).

Table 1. Mean and SD of the number of words correctly identified by all the groups

Groups	Number	Mean age (years)	Range (years)	SD (years)	Mean (keywords correctly identified/ percentage scores)	SD
Normal hearing	40	28.9	18–55	8.2	39.4 (98.6%)	0.15
Mild hearing loss	10	27.0	18–38	7.1	39.5 (98.8%)	0.13
Moderate hearing loss	10	42.0	20–60	16.2	36.9 (92.3%)	1.80
Moderately severe hearing loss	10	41.6	27–60	13.0	24.6 (61.4%)	3.12
Severe hearing loss	10	45.7	25–69	15.7	19.3 (48.2%)	3.10

Table 2. Results of Mann–Whitney *U*-test comparing the number of words correctly identified between different groups

Groups	*Z*-value	*p*-value
Mild vs. Moderate	3.78*	<0.001
Mild vs. Moderately-severe	3.78*	<0.001
Mild vs. Severe	3.78*	<0.001
Mild vs. Normal	1.87	0.630
Moderate vs. Mild	3.78*	<0.001
Moderate vs. Moderately-severe	3.78*	<0.001
Moderate vs. Severe	3.78*	<0.001
Moderate vs. Normal	4.87*	<0.001
Moderately-severe vs. Mild	3.78*	<0.001
Moderately-severe vs. Moderate	3.78*	<0.001
Moderately-severe vs. Severe	3.02*	<0.001
Moderately-severe vs. Normal	4.87*	<0.001
Severe vs. Mild	3.78*	<0.001
Severe vs. Moderate	3.78*	<0.001
Severe vs. Moderately-severe	3.02*	<0.001
Severe vs. Normal	4.87*	<0.001

Note: *$p < 0.001$; Mild = group with mild hearing loss; Moderate = group with moderate hearing loss; Moderately-severe = group with moderately-severe hearing loss; Severe = group with severe hearing loss; Normal = group with normal hearing

Results

The clinical utility of the developed sentence material was evaluated in 40 individuals with hearing loss and 40 individuals with normal hearing. The clinical group consisted of participants with mild, moderate, moderately-severe, and severe sensorineural hearing loss (10 participants each).

Between-group comparison

Table 1 gives the mean and SD of correctly identified words (averaged for all the lists) for all 5 groups. The mean value decreases with increase in the degree of hearing loss, although the scores are comparable between the normal and mild groups.

A Kruskal–Wallis statistical analysis was done to evaluate if the difference in mean identification scores was statistically significant. The results revealed that a statistically significant difference between groups was present ($p < 0.001$). Hence, a pair-wise comparison was made using a Mann–Whitney *U*-test, and the results are given in Table 2. The table shows that the difference was significant ($p < 0.001$) between all the groups except between mild hearing loss and normal hearing groups ($p = 0.630$).

Table 3. Mean and SD of the number of words repeated correctly for the 25 lists by individuals in the mild group ($n = 10$)

List No.	Mean	SD
List1	39.8	0.63
List2	39.4	0.97
List3	39.7	0.48
List4	39.5	0.71
List5	39.7	0.67
List6	39.8	0.42
List7	39.8	0.42
List8	39.5	0.70
List9	39.5	0.71
List10	39.2	1.03
List11	39.4	0.70
List12	39.7	0.48
List13	39.8	0.42
List14	39.7	0.48
List15	39.6	0.84
List16	39.5	0.85
List17	39.4	0.84
List18	39.3	0.82
List19	39.6	0.70
List20	39.1	1.00
List21	39.6	0.63
List22	39.6	0.97
List23	39.1	0.69
List24	39.5	0.99
List25	39.6	0.69

Within-group comparison

To validate the equivalency of the lists in the hearing impaired population, within-group comparison of the scores across different lists were made for the four groups

Table 4. Mean and SD of the number of words repeated correctly for 25 lists by individuals in the moderate group ($n = 10$)

List No.	Mean	SD
List1	37.2	2.70
List2	36.8	3.29
List3	38.4	1.50
List4	37.2	1.93
List5	37.1	2.33
List6	35.8	4.10
List7	36.5	3.24
List8	37.1	2.72
List9	36.2	2.25
List10	36.7	2.31
List11	36.3	2.16
List12	36.4	2.59
List13	36.7	3.19
List14	37.6	2.95
List15	38.5	1.64
List16	37.5	1.84
List17	37.1	1.91
List18	37.3	2.40
List19	37.2	2.93
List20	36.3	2.83
List21	36.2	2.65
List22	35.8	2.34
List23	37.0	2.30
List24	36.9	3.38
List25	37.5	2.79

Table 5. Mean and SD of the number of words repeated correctly for 25 lists by individuals in the moderately-severe group ($n = 10$)

List No.	Mean	SD
List1	20.9	3.75
List2	23.3	2.40
List3	25.3	4.00
List4	25.4	3.86
List5	23.0	6.81
List6	25.4	4.11
List7	26.7	4.16
List8	24.2	5.00
List9	24.9	4.60
List10	25.7	4.73
List11	25.2	4.54
List12	24.7	5.71
List13	23.7	3.74
List14	24.2	4.49
List15	24.3	4.85
List16	24.7	4.29
List17	25.0	3.43
List18	25.3	4.92
List19	23.6	4.52
List20	25.0	5.12
List21	22.2	7.95
List22	24.8	3.96
List23	25.4	2.59
List24	25.9	2.99
List25	25.6	4.29

of individuals with hearing impairment. Table 3 gives the mean and SD of the number of correctly identified words for 25 lists for the mild group.

Table 3 shows that the mean and the standard deviation do not vary across the lists. Repeated measures ANOVA was carried out to compare the scores across different lists, and there was no significant difference $F(24,216) = 0.802$, $p > 0.05$ between the lists for the scores obtained from individuals with a mild degree of hearing loss. Tables 4, 5, and 6 consist of the mean and SD of the number of correctly identified words for 25 lists for the moderate, moderately-severe, and severe groups, respectively. It can be observed that even in these groups, the mean does not vary across the lists.

Repeated measures ANOVA also revealed no significant difference for the moderate group [$F(24,216) = 1.161$, $p > 0.05$], moderately-severe group [$F(24,216) = 1.347$, $p > 0.05$], and severe group [$F(24,216) = 1.496$, $p > 0.05$]. These results suggest that the mean number of correctly identified words does not vary across the lists in any of the four groups, suggesting equivalency across the standardized 25 lists.

Discussion

The current study aimed to assess the clinical utility of the standardized Kannada sentence lists developed by Geetha et al. [15] by comparing the number of correctly identified words across different degrees of hearing loss, and different lists within each degree of hearing loss. It was observed that the mean value decreased with an increase in the degree of hearing loss. However, scores were comparable between the normal and mild groups. These results are consistent with the fact that as the extent of hearing loss increases, perceptual difficulties also increase. The most quoted reference for the lower limits of speech identification scores for different degrees of cochlear pathology is Yellin et al. [21]. They reported lower limits of 68%, 38.5%, 24%, and 11% for mild, moderate, moderately-severe, and severe cochlear pathology, respectively. The scores obtained by Yellin et al. are below the lower limits found in the present study. The reason is probably that that Yellin et al. [21] used synthetic sentences, which are likely to have considerably increased the difficulty, and thereby reduced the scores.

Table 6. Mean and SD of the number of words repeated correctly for 25 lists by individuals in the severe group ($n = 10$).

List No.	Mean	SD
List1	18.1	3.90
List2	19.1	3.81
List3	18.6	3.89
List4	16.9	3.69
List5	17.7	3.86
List6	18.7	4.83
List7	21.4	4.35
List8	19.1	3.92
List9	20.8	5.20
List10	19.3	4.90
List11	20.4	4.69
List12	19.4	3.23
List13	18.7	3.30
List14	19.8	2.74
List15	19.6	4.16
List16	19.4	3.13
List17	21.1	4.22
List18	20.2	3.61
List19	19.8	4.56
List20	19.5	3.59
List21	18.2	3.85
List22	19.6	4.27
List23	20.1	3.81
List24	18.3	3.02
List25	18.6	4.88

Further, the effects of severe hearing loss on speech identification scores have also been well reported. The drastic decrease in speech identification ability in these individuals may be attributed to the loss of cochlear nonlinearity, decreased frequency selectivity, decreased temporal resolution, increased upward spread of masking, and the possible presence of dead regions [22–24]. This could also result in poor speech perception, even in quiet [25].

In addition, the results reveal that the sentence material is sensitive to differences in speech identification ability across different degrees of hearing loss. That is, there is a significant decrease in scores in severe hearing loss individuals when compared to mild to moderate degrees of hearing loss. Similar results have been demonstrated in well-used speech tests like HINT [26] and the CID Everyday sentences list [27]. This could be because individuals with severe hearing loss have much more loss of audibility and spectral resolution than in individuals with mild to moderate degrees of hearing loss [28]. This supports the idea of using the developed sentence lists for routine clinical examination as well as for research studies.

To validate the equivalency of the lists in the hearing impaired population, within-group comparison of the scores were made for the four groups of individuals with hearing impairment. The results revealed that there was no significant difference between the lists in any of the hearing loss groups. These results suggest that the mean number of correctly identified words does not vary across the lists in any of the four groups, suggesting equivalency across the standardized 25 lists. Any test should aid in comparing a large number of different variables of interest, and the results should reflect the actual differences between the conditions. That is, the differences should not be due to differences in the lists [29]. Hence, from the results, it can be said that the test developed in the present study can aid in comparisons across a large set of test conditions for different degrees of hearing loss in quiet.

Applications

The sentence test has been developed using many tedious steps so that the test could incorporate equivalent sentences and that they could measure speech perception precisely. Hence, several published research studies have already used these sentence lists. Mathai and Mohammed [30] assessed the effect of compression release time in hearing aids and presentation levels on sentence perception in the presence of noise using the SNR-50 task on normal hearing and hearing-impaired elderly individuals. Geetha, Tanniru, and Rajan [31] evaluated the benefit of directionality in wireless hearing aids in individuals with hearing impairment. In their study, the speech perception in noise was assessed using the SNR-50 task with the sentences developed by Geetha et al. [15]. Shetty and Nanjundaswamy [32] evaluated the effect of noise reduction strategies in hearing aids on annoyance and speech perception in individuals with hearing loss. Megha and Maruthy [33] have also used the sentences to assess the perceived benefit of hearing aid acclimatization; Shetty and Pottackal [34] have quantified the amount of gain variation in a hearing aid required to cause a change in the tinnitus percept.

In another study by Jain and Nataraja [35], based on two groups of young and older individuals with normal hearing and hearing loss, the sentences were used to assess the role of temporal envelope and temporal fine structure in the ability to perceive sentences in quiet and noise. In another study in 2019, the same authors used the same sentence lists to evaluate the correlation between temporal integration and temporal envelope perception in noise [36]. The sentences have also been used to study the effect of the number of talkers in background speech babble on acceptable noise levels [37] and the effect of compression, digital noise reduction, and directionality on envelope difference index, log-likelihood ratio, and perceived quality [38].

Conclusions

All the 25 lists were equivalent in terms of difficulty, and the lists were also sensitive enough to differentiate different degrees of hearing loss, giving lesser scores for individuals with higher degree hearing loss versus those with a lower degree of loss. It can be concluded from the results that these list can be efficiently used for measurement of speech intelligibility or SNR-50 measures in various applications such as hearing evaluation in different conditions, and can also be used in adults for evaluating the benefits of hearing aids on speech perception by varying different parameters of hearing devices.

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