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Original Article

Objective Measure of Listening Effort in Hearing-Impaired Individuals With and Without Tinnitus

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BACKGROUND: Tinnitus is a perception of sound in the brain without any external stimulus. Tinnitus patients often complain of more efforts required in listening. They may be ineffective in inhibiting their attention, driven to irrelevant ringing sounds in their ear rather than attending to the relevant target speech stimulus. The study's objective was to evaluate an allocation of cognitive resources among tinnitus patients for concurrent tasks required for understanding speech using an objective dual-task paradigm to assess listening effort.

METHODS: We recruited 40 participants with mild to moderately severe sloping sensorineural hearing loss within 60-70 years. They were subgrouped into control and clinical groups. The clinical group had a severe degree of tonal tinnitus bilaterally. The objective listening task used listening effort, and a subjective questionnaire to assess the effort in listening was assessed by each study participant.

RESULTS: The results indicated poorer recognition and reduced recall scores in a clinical group than the control group in each signal-to-noise ratio. The recall score in objective listening effort measurement was strongly correlated with subjective questions assessed effort in listening among the clinical group at each signal-to-noise ratio. However, in the control group, the correlation was to a mild degree at 0 dB signal-to-noise ratio only.

CONCLUSION: Annoyance caused by tinnitus disrupts attention, thereby limiting the effective use of cognitive resources for concurrent speech processing and recalling reflected in the listening effort task.

KEYWORDS: Ringing, working memory, hearing loss, attention

INTRODUCTION

Tinnitus is the perception of sound in the absence of an external sound source,[1] and it is more common in older adults[2] with hearing loss.[3] Tinnitus is associated with a wide range of problems and is commonly reported as sleep disturbance, annoyance, and reduced quality of life.[4] A problem in concentration among individuals with tinnitus makes speech understanding more difficult than hearing loss alone.[5] It is assumed that tinnitus disrupts attention and working memory. Research reports on cognitive function can support the evidence of this assumption. Hearing-impaired individuals with tinnitus had a slower response time in discrimination tasks and memory-loaded tasks than those without tinnitus. The effect was more pronounced with the high memory-loaded task. Further, the functional magnetic resonance image (fMRI) substantiated the behavioral response, and results revealed that the attention processing region in the brain was depressed in individuals with tinnitus when stimuli are presented in auditory mode.[6] In addition, the individuals with tinnitus have impairment in divided attention reflected in slower reaction time in the Stroop task.[7] The attention is preoccupied with continuous ringing sensations that stress the available cognitive resource as attention is divided into several tasks. The cognitive resource hypothesis was tested using a memory-loaded dual task in individuals with tinnitus who showed slower reaction time and poorer recalling of words.[8] It suggests that individuals with tinnitus have difficulty inhibiting their attention driven to irrelevant tinnitus signals rather than attending to the relevant target stimulus. This gives a notion that a client with tinnitus has to put in extra effort to surpass the ringing sound as attention is simultaneously being utilized in rehearsal, putting sounds into short-term memory, and later recalling it for speech understanding. Attention and working memory are related to speech understanding[9] and may become effortful listening for a person with tinnitus because of ineffective allocation of cognitive resources to pursue simultaneous tasks.

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The dual-task paradigm is the most accurate method available to assess the allocation of cognition resources. The dual-task paradigm is derived from the capacity theory of attention developed by Kahneman.[10] The dual-task paradigm assesses the brain's information processing when performing the primary task while conducting a simultaneous secondary task. In the primary task, the sentences are presented sequentially in the presence of noise at different SNRs, and the client is instructed to repeat the last word of the sentence, which requires mental capacity. In the secondary task, the client is encouraged to recall the repeated words using spare mental capacity. A condition that is making the primary task difficult results in lesser cognitive reserve to spare in performing the secondary task.

Age-related hearing loss has an impact on listening efforts.[11] It could be due to allocating more selective attention for attending to speech (primary task) and the limited cognitive reserve available to spare other tasks such as storing information in memory, solving ambiguity by contextual cues, and finally generating a quick response to speech (secondary task). It indicates that more cognitive reserves are allocated for the initial processing of speech perception, leaving a fewer reserve for subsequent recall. The literature shows that a significant amount of annoyance and imbalance in emotion among tinnitus patients disrupt the performance of cognition tasks.[12] It is hypothesized that older adults with hearing loss having tinnitus may have to spend more effort in listening than older adults with hearing loss alone, who are matched with possible confounding variables such as age, education, and hearing threshold. Further, none of the participants had dementia. The reason is that the cognitive resource for processing the speech may be more taxed by the tinnitus and left with only limited cognitive resources to perform a concurrent secondary task for comprehension of speech results in effortful listening. Thus, this study aimed to determine the effect of chronic tinnitus on listening effort in hearing-impaired older adults. To the best of our knowledge, no research has been conducted related to listening efforts among older adults with a hearing loss having with and without tinnitus. A more specific objective of this study was to compare the recognition score (primary task) and recall score (secondary task) between individuals with hearing impairment with tinnitus (clinical group) and without tinnitus (control group). Further, the recall score was correlated with the subjective questions about the effort in listening. The findings of this study may provide more discernment into attention and concentration difficulties related to speech processing and later recalling the speech among individuals with hearing loss comorbid with and without tinnitus.

MATERIAL AND METHODS

We have used the standard group research design to evaluate the listening effort in individuals with hearing-impairment with and without tinnitus.

Participants

The purposive sampling method was used to select 40 participants for the study, and they were grouped into 2 namely, clinical and control groups. A minimum sample size of 17 was estimated to provide strong 80% statistical power with a medium effect size ($f^2=0.5$) using Cohen's *d* effect size method in considering the data of listening effort in individuals with tinnitus.[13] Additional 3 participants were included in the minimum sample size to make 20 participants in each group.

In the clinical group, 20 participants who had hearing loss comorbid with tonal tinnitus were recruited within the age group of 60-70 years [mean age = 64.2 (years); SD = 2.9 age (years)]. Those participants who had bilateral tinnitus <6 months with a severe degree of tinnitus handicap inventory were involved. In the control group, 20 participants of hearing-impaired individuals having no tinnitus within the age range of 60-70 years [mean age 63.5 (years); SD = 2.87 age (years)] were involved. Table 1 shows the demographic and clinical characteristics of the participants in 2 groups.

All the participants had acquired bilateral mild-to-moderately severe gradually sloping sensorineural hearing loss, and hearing threshold from 250 Hz to 500 Hz was ≥ 25 dB HL, 1000 Hz to 2000 Hz was ≥ 45, and from 3000 to 8000 Hz was ≥ 65 dB HL. The possible etiology of hearing loss in both groups is age related. Participants in each group had normal middle ear status indicated by type "A" tympanogram. All the participants are full-time bilateral hearing aid users and have used their devices for at least 6 months. The participants were native speakers of Kannada and geographically located in and around Mysore. Montreal Cognitive Assessment (MoCA) was administered to screen to rule out dementia and cognitive impairment, and those participants who scored greater than 21 were recruited.[14] An independent-samples *t*-test was performed, and the results revealed no significant difference between control and clinical groups in terms of age, pure tone average of right and left ears, and scores of MoCA.

Ethical Consideration

In the present study, all the tests performed on each participant are non-invasive techniques. All the test procedures were approved by the human Ethics committee of the Jagadguru Sri Shivarathri deshikendra mahaswamiji Institute of Speech and Hearing (JSSISH) (JSSI SH/EC/110/2021-22). Informed consent was obtained from each participant by explaining the procedure and time allocated for data collection.

The Tinnitus Handicap Inventory

The Tinnitus Handicap Inventory (THI) originally developed by Newman et al[15] and adopted in Kannada Language[16] was used to investigate the handicap from tinnitus among participants of the clinical group. Tinnitus Handicap Inventory consists of 25 questions that assess the degree of severity of tinnitus. Each question was answered on 3-point rating scale "yes," "sometime," and "no" and awarded scores of 4, 2, and 0, respectively. The THI scores range from 0 to 100 points, corresponding to a degree of severity [very mild (0-16), mild (18-36), moderate (38-56), severe (58-76), and catastrophic (78-100)]. Those participants who scored between 58 and 76 were recruited for the study.

Listening Effort

The dual-task paradigm procedure developed by Pichora-Fuller and colleagues[17] was utilized to assess listening effort. It consists of primary and secondary tasks. In the primary task, the participant has to repeat the last word of the sentence. In the secondary task, the

Table 1. Detailed Information on Demographic and Clinical Characteristics of Control and Clinical Participants

	Clinical Group								Control Group				
SI	Age (Years)/ Gender	PTA (R)	PTA (L)	Pitch Matching (Hz)	Loudness Matching	Education	Duration of Tinnitus (Months)	MoCA	Age (Years)/ Gender	PTA (R)	PTA (L)	Education	MoCA
1	68/M	40.3	30.3	4 kHz	50	1	6	28.00	61/M	30.3	30.3	2	22.00
2	66/M	50.6	45.6	3 kHz	45	2	5	26.00	64/M	40.6	45.6	1	26.00
3	60/M	45.6	40.6	2 kHz	50	1	4	27.00	63/F	35.8	40.6	3	22.00
4	64/M	40.3	35.3	4 kHz	60	3	5	23.00	62/M	50.6	45.3	1	22.00
5	60/M	45.3	40.3	1 kHz	40	1	5	26.00	68/M	45.2	40.6	3	26.00
6	62/M	50.5	40.5	4 kHz	55	2	4	23.00	66/M	40.3	35.5	1	25.00
7	66/M	35.3	45.3	3 kHz	40	2	3	22.00	67/M	45.8	45.3	1	28.00
8	61 /M	33.8	36.8	4 kHz	45	1	3	26.00	61 /M	43.8	35.8	3	24.00
9	67/M	45.3	40.3	4 kHz	50	3	6	24.00	60/F	35.3	40.3	1	27.00
10	63/M	41.6	41.6	0.5 kHz	30	1	4	27.00	61/M	31.3	51.6	2	24.00
11	61/F	43.3	43.3	3 kHz	45	3	5	23.00	68/F	33.3	43.3	2	27.00
12	63/M	45.3	45.3	4 kHz	55	1	6	28.00	63/F	45.3	50.3	1	26.00
13	64/F	51.6	51.6	2 kHz	50	1	5	28.00	64/F	41.3	45.6	2	22.00
14	68/F	45.3	45.3	1 kHz	40	1	4	23.00	68/F	55.6	45.3	1	26.00
15	67/M	50.3	50.3	6 kHz	55	2	6	24.00	67/M	40.6	45.3	2	25.00
16	66/F	45.3	45.3	8 kHz	65	2	2	28.00	61/F	35.6	40.3	1	26.00
17	64/M	38.3	38.3	4 kHz	60	1	3	26.00	63/F	48.6	35.3	2	26.00
18	63/F	42.6	42.6	2 kHz	45	3	3	23.00	63/F	42.3	40.6	1	24.00
19	70/M	39.3	39.3	4 kHz	55	2	2	26.00	60/M	43.3	40.3	3	25.00
20	61/F	43.8	43.8	3 kHz	50	1	4	25.00	60/M	43.3	45.8	1	24.00
Mean	64.20	43.68	42.08					25.30	63.50	41.95	42.15		24.80
SD	2.39	4.93	4.93					2.02	2.87	4.92	5.24		1.81
	Age	PTA (R)	PTA (L)	MoCA									
Test	0.760	0.978	0.95	0.739									
P	0.450	0.334	0.253	0.340									

Education: UG -1, PG-2, and Diploma-3; MoCA, Montreal Cognitive Assessment; PTA, pure tone average; SD, standard deviation.

participant has to recall all the words repeated in a block. The performance of the recall task reflects the listening effort. In the present study, each block consisted of five sentences.

Stimulus Preparation

The listening effort software[18] (AIISH, India) was loaded into a personal laptop having the specification of an Intel (R) Core (TM) i5 processor, 4 GB RAM, and a 64-bit operating system with the standard sound card. A new project was created in the software. The target Kannada sentences were considered. Twenty-four lists of standardized Kannada sentences[19] were used as the target test stimuli in the dual-task paradigm to assess listening effort. Each list consisted of 10 familiar sentences. Each sentence has 5 target words. All the lists of sentences are phonemically and phonetically balanced. These target sentences were loaded as the "Speech files." The speech-shaped noise generated was uploaded as the "Noise file." We have adopted the method given by Versfeld[20] to generate the speech-shaped noise with a simple finite impulse response filter matching the spectrum for the speech target.

Procedure

The listening effort was determined at 0 dB signal-to-noise ratio (SNR) (less favorable) and 4 dB SNR (relatively favorable condition). The schema of the listening effort test is given in Figure 1. Calibration was performed before the actual test. A pure tone of 1 kHz was presented at 82 dB SPL. The laptop's volume was increased/decreased until the output through the headphone reads at 82 dB SPL in the sound level meter.

A total of 240 standardized Kannada sentences were used. Totally 120 sentences were mixed with speech-shaped noise at 0 dB SNR. Another 120 sentences were mixed with noise at 4 dB SNR. In the listening effort, the recall number was set at "5," so there were 5 target sentences in each block. A target standardized Kannada sentence mixed with the speech-shaped noise was presented sequentially through the headphone bilaterally at the participant's most comfortable level. Each participant was instructed to repeat the last word of every sentence presented (primary task). They are also encouraged to guess the words if they are uncertain. Each participant was asked to remember their responses as they would have to recall the words later. The interstimulus interval (ISI) was set at 3000 ms. The ISI is the time between the end of the previous sentence and the beginning of the next sentence. After the presentation of 5 sentences, an audio beep (pure tone of 200 ms) was played. It was an indication for the participant to recall the words repeated in the primary task (secondary task). The interblock interval was set at 10 000 ms. The inter-block interval (IBI) is the time between the end of the previous block and the start of the next block. There were 24 blocks per SNR [number of sentences/recall number (120/5)]. From 2 SNRs, 48 blocks were

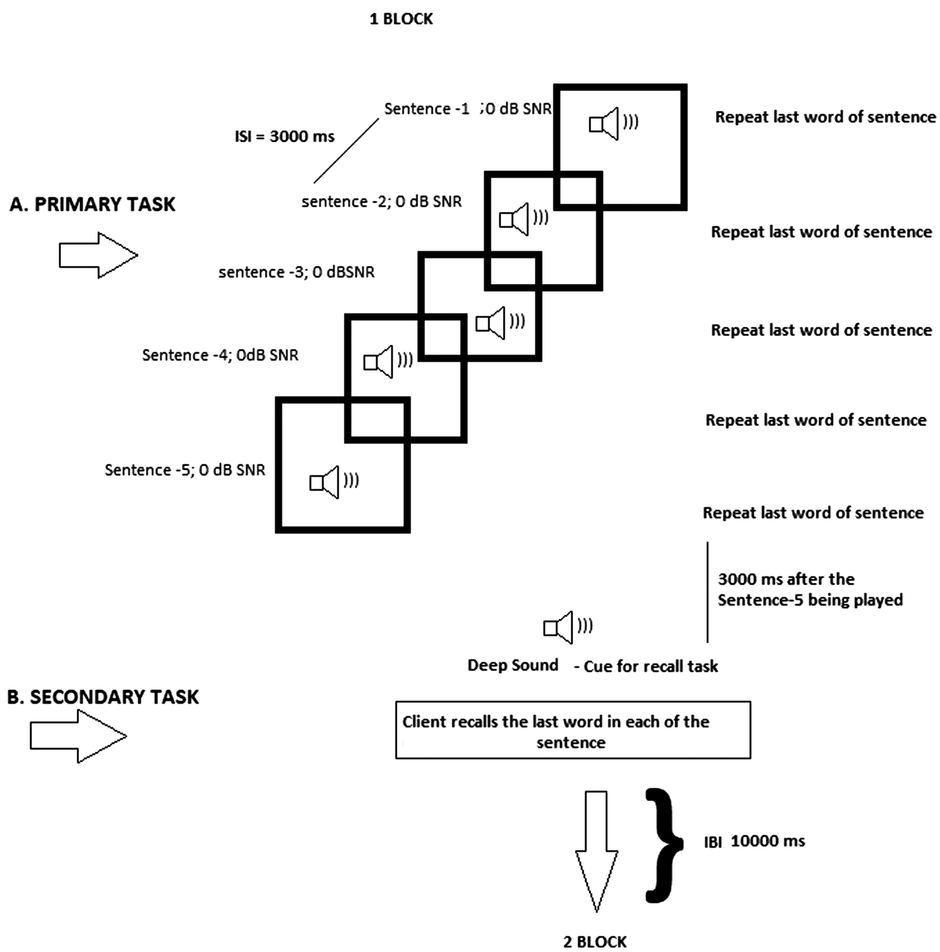

Figure 1. Each block comprised 5 sentences. The 5 sentences mixed at noise at 0 dB SNR are delivered sequentially with an inter-stimulus interval of 3000 ms. The client repeats the last word of the sentence. An audio beep of 200 ms duration is played after the end of the last sentence. The client has to recall the last word of the sentence. The next block is started after 10 000 ms from the end of recall task of previous block. SNR, signal-to-noise ratio.

generated. The 48 blocks from 2 SNRs were presented in random order, and responses to primary and secondary tasks from each SNR were scored separately, which is explained in the analysis section.

Scoring

A score of 1 was awarded for a correct response, and a score of 0 was assigned for incorrect or no response for the primary and secondary tasks. With 5 sentences in each of the 24 blocks (block count per SNR), the maximum recognition score per SNR was 120. Similarly, the maximum score per block for the recall task was 5 (irrespective of the order). It was true for every block of each SNR. The scores were represented as (a) recognition scores and (b) recall scores.

Primary Task – Recognition Score

Raw score = ∑ Sum of scores in each block

Percentage score = Raw score /Recall count in each block * (no of blocks per SNR) * 100

Secondary Task – Recall Score

Raw score = ∑ (recall score/recall count in each block)

Percentage score = (raw score/no of blocks per SNR) * 100

Subjective Listening Effort

The participants rate their subjective listening effort as of paramount importance. This is because if a participant does not notice a change in effort in listening subjectively, the objectively measured change in listening effort, although statistically significant, may not be clinically useful. We used 3 questions of subjective listening effort from the speech, spatial, and qualities of hearing scale developed by Gatehouse and Noble.[21] For this study, the questions were slightly modified but semantically similar. Each participant rated their current concentration level [How well can you concentrate when listening to a sentence in the presence of noise? (1 = concentrate hard; 10 = do not need to concentrate)], effort [Do you have to put in a lot of effort to listen to what is being said in the sentence in the presence of noise? (1 = lot of effort; 10 = no effort)], and ignorance [How well can you easily ignore noise when trying to listen to the sentence?] on a 10-point rating scale (1 = easily ignored; 10 = very difficult to ignore). These questions were administered after the dual-task objective listening effort test, and each participant was instructed to provide a subjective estimate of listening effort in each of the SNRs.

RESULTS

The data were subjected to the Statistical Program for Social Science (version 21) (IBM, New York, United States). The present study investigated the listening efforts in hearing-impaired individuals with and without tinnitus. As expected, the recognition score and recall score were reduced at 0 dB SNR (less favorable condition) than at 4 dB SNR (favorable condition). It is true in each group. In addition, the recognition score and recall score at each of the SNRs were reduced in the clinical group than in the control group. Furthermore, the performance on the recognition task expresses the amount of effort put in on the recall task. The performance score was reduced in the recognition task and required more effort to recall the repeated words in less favorable conditions (0 dB SNR) than in favorable conditions (4 dB SNR). The pattern of the above findings was found in each group, and it is pronounced in the clinical group.

Recognition Scores (Primary Task)

A one-way analysis of variance (ANOVA) (SNR) with between-subject factors as the group was performed to compare the effect of group and SNR on recognition scores. The results revealed a significant interaction effect of SNR*Group [F (1, 38) = 0.009, P = .05] on recognition score. The main effect of SNR was found significant, indicating that the recognition score at 0 dB SNR (less favorable condition) was significantly lesser than 4 dB SNR (favorable condition) [F (1, 38) = 69.33, P = .001]. Similarly, the main effect of the group was found significant in the recognition score. The recognition score was significantly reduced in the clinical group than in the control group [F (1, 38) = 31.98, P = .001]. Further, an independent samples t-test was performed to determine in which SNR the recognition score was significant between groups.

The results revealed that there was a significant difference in the recognition score between the groups (t (38) = -5.41, P = .001) at 0 dB SNR (less favorable condition), indicating that the recognition score was significantly lesser in the clinical group than the control group (Figure 2). A similar result was noticed at 4 dB SNR (t (38) = -5.42, P = .001) (favorable condition).

Recall Scores (Secondary Task)

A one-way ANOVA (SNR) with between-subject factors as the group was conducted to compare the effect of group and SNR on recall scores. The results revealed a significant interaction effect of SNR*Group [F (1, 38) = 0.11, P = .048] on recall scores. The main effect of SNR was found to be significant, indicating that the recall score was significantly lesser at 0 dB SNR than 4 dB SNR [F (1, 38)= 46.92, P = .001]. Similarly, the main effect of "group" was significant in that the recall score was lesser in the clinical group than in the control group [F (1, 38) = 32.97, P = .001]. Further, an independent sample t-test was conducted to investigate in which SNRs the recall score was found to be significant between groups.

The results revealed that there was a significant difference in recall score between the groups (t (38) = -5.80, P = .001) at 0 dB SNR indicating that the recall score was significantly lesser in the clinical group than in the control group (Figure 3). A similar result was noticed at 4 dB SNR (t (38) = -5.07, P = .001) on recall score.

Relationship Between Objective and Subjective Effort in Listening

In the dual-task paradigm, the recall score (secondary task) measures the listener's effort to recall the repeated words (primary task). Thus, the recall score was used as a listening effort from here onwards and correlated with the subjective questions that assessed the effort in listening. The participant's listening effort was obtained from the dual-task paradigm at 2 SNRs. Their subjective listening effort documented from the questions was correlated using a Pearson product-moment correlation coefficient test (Table 2). In the clinical group, irrespective of the SNRs, the results revealed a significant strong positive relationship between objective listening effort and the subjective questions assessed the effort in listening reflected in "concentration" and "effort." In addition, a significantly strong negative relationship was found between objective listening effort and questions pertaining to "ignoring the background noise" of subjective effort in listening. However, only in favorable conditions in the control group, a significant mild positive relationship was found between objective listening effort and subjective

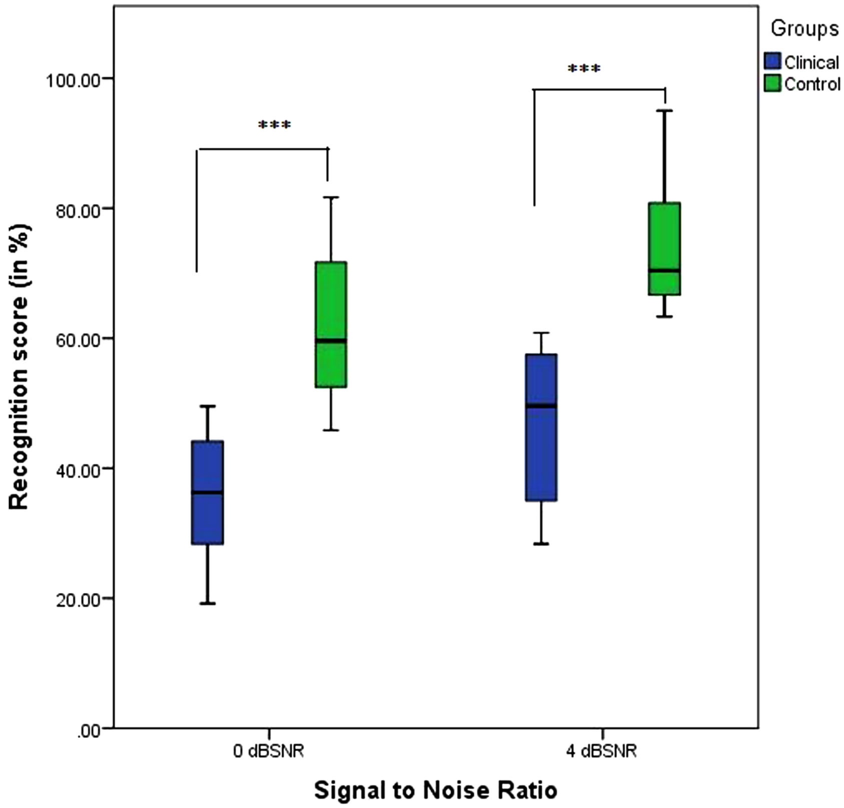

Figure 2. Box plot showing the recognition scores of the primary task obtained at different SNRs for control and clinical groups. SNR, signal-to-noise ratio.

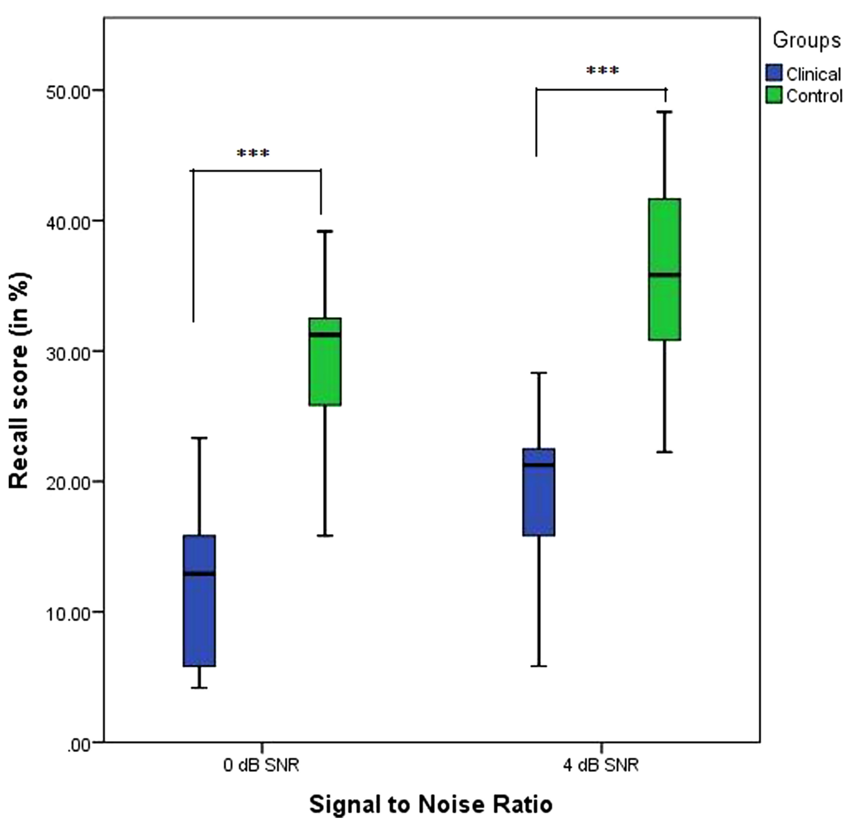

Figure 3. *Box plot shows* the secondary task's recall scores for control and clinical groups at different SNRs. SNRs, signal-to-noise ratios.

Table 2. The Correlation Coefficient *r*-Value and *p*-Value Between Subjective and Objective Listening Effort (n = 20; df = 18) and the Mean and the SD of Listening Effort Obtained From 0 dB SNR and 4 dB SNR Among Control and Clinical Groups

Groups	Parameters	0 dB SNR				4 dB SNR			
		Subjective Listening Effort, Mean (SD)	Objective Listening Effort, Mean (SD)	*P*	*t*-value	Subjective Listening Effort, Mean (SD)	Objective Listening Effort, Mean (SD)	*P*	*t*-value
Control	*Concentration*	7.9 (3.8)	29.16 (6.90)	**.436**	**0.045***	8.9 (3.4)	35.89 (7.70)	.201	0.585
	Effort	7.4 (3.1)		**.452**	**0.039***	8.4(3.1)		.241	0.425
	Ignoring noise	3.4 (2.3)		**−.321**	**0.048***	2.5(2.5)		−.130	0.357
Clinical	*Concentration*	4.2 (2.28)	11.99 (6.31)	**.897**	**0.001*****	6.9(3.3)	19.41 (6.79)	**.869**	**0.001*****
	Effort	5.1 (2.8)		**.768**	**0.001*****	7.1(3.1)		**.754**	**0.001*****
	Ignoring noise	7.29 (3.7)		**−.751**	**0.001*****	6.1(2.7)		**−.897**	**0.001*****

SNR, signal-to-noise ratio; SD, standard deviation.
***$P = .001$; *$P = .05$.

listening effort question reflected in "concentration" and "effort." In addition, a significantly strong negative relationship was noticed between the objective listening effort test, and the question pertained to "ignoring the background noise" of subjective effort in listening.

DISCUSSION

The goal of the study was to investigate the listening efforts in individuals with hearing loss with and without tinnitus. The performance of the primary task (recognition score) tells us the amount of effort the listener puts into the secondary task (recall scores). As expected, the recognition score was decreased when the SNR was reduced, and the participants exerted more listening effort in recalling the repeated words in the primary task. The control group participants showed a significant relationship between effort in listening assessed subjectively and objectively measured changes in listening effort. It is because the inherent cues in speech are partly lost and distorted due to noise at reduced SNR. An unclear speech impinges on the listener's ear and is further distorted by impaired cochlea among older adults with hearing loss before reaching the brain. Finally, the resultant speech does not represent what the brain is tuned to process. Thus, in the perception stage brain puts a lot of effort just into attending to the speech by ignoring the noise, and over a period of time participant's concentration reduces, reflected in the subjective questions. In the subsequent stages, the sentences to which attention was provided by ignoring the noise to repeat the last word were rehearsed and integrated for later recall. This process may sometimes exceed working memory capacity limits and result in a reduced performance score in the secondary task in less favorable conditions.

A common complaint by older adults with tinnitus is an inability to follow speech and more effort required in listening. Irrespective of the SNRs, the results showed a significant listening effort from individuals with tinnitus than those without tinnitus. In addition, the efforts assessed by subjective questions in listening significantly correlated with objectively measured change in the listening effort at each SNR. In the clinical group, a ringing sound perceived in the ear makes the participants inevitably give focused attention to the tinnitus, and relatively lesser attention was provided to the sentence to mine the last word in the presence of noise. Furthermore, the noise distorts an essential cue in speech, making the participants concentrate more to recognize the last word of the sentence by ignoring the noise. An available limited mental capacity of attention was recruited for subsequent processing of storing information into memory, rehearsing the words, and finally recalling the words resulting in effortful listening. Although the pattern of recall was not systematically analyzed, it was found that a few initial words (primacy effect) and the last word (recency effect) were recalled. However, they find it difficult to recall the middle words (asymptote). The results on the pattern of recall score are in consonance with the research report of Lunner et al.[22] The attributed reason could be the availability of more cognitive resources to segregate the speech from noise. With the available resource, they had managed to rehearse a few initial words and put them in the short-term memory for later recall and left with relatively lower or no reserve to recall the middle order words, which were recognized in the primary task.

The listening effort increases with the advance in age, and its effect is more when the listening condition changes from favorable to less favorable condition. The age-related cognitive and sensory decline starts at 40 years and above (24-27). Although the possible confounding variables such as age, hearing threshold, education, and working memory between groups were matched, the effort put in by the clinical group was relatively more than the control group. The effort in listening among participants of the clinical group was because attention provided to the ringing sound in their ears might have limited the optimum use of cognitive resources for subsequent processing. Thus, the alternative hypothesis is accepted that the individuals with tinnitus having hearing loss showed more effortful listening than individuals without tinnitus.

Clinical Implication

The findings of the study suggest effortful listening among participants having tinnitus. It is because of disrupted attention skills due to the annoyance caused by tinnitus. In tinnitus patients, a larger cognitive resource was required to recognize the last word of the sentence by ignoring the ringing sound and the noise. A limited available resource was used for subsequent processing, such as putting the last words into short-term memory and rehearsing and recalling the repeated words. Individuals with hearing impairment with tinnitus require voluntary, conscious, and strategic control for effective and optimum use of cognitive resources to understand speech.

Limitations of the Study

Cognitive functions are essential for speech communication. Although the listening effort is the best possible test to assess cognitive function meant for speech perception, it requires time unable to accommodate in the current routine clinical practice.

Ethics Committee Approval: Ethical committee approval was received from the Human Ethics Committee of the JSS Institute of Speech and Hearing (Approval No: JSSISH/EC/110/ 2021-22).

Informed Consent: Written informed consent was obtained from all participants who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – H.N.S., S.R.; Design – H.N.S., S.R.; Supervision – H.N.S., S.R.; Resources – H.N.S., S.R.; Materials – H.N.S., S.R.; Data Collection and/or Processing – H.N.S., S.R.; Analysis and/or Interpretation – H.N.S.; Literature Search – H.N.S., Writing – H.N.S.; Critical Review – H.N.S.

Declaration of Interests: The authors have no conflict of interest to declare.

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