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# Test-retest reliability of dichotic listening test in younger adults with normal hearing

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## Abstract

**Background** Dichotic listening refers to simultaneously stimulating both ears but with two different stimuli. Dichotic listening tasks were used in the audiological test battery to assess auditory processing abilities in children and adults. Studies have reported the dichotic consonant-vowel syllable test's test-retest reliability in different attentional manipulation conditions. The objectives are to measure the intra- and inter-test reliability of dichotic consonant vowel tests in young, healthy individuals.

**Methods** Sixty participants aged 18–28 with normal hearing sensitivity were recruited for the study. To measure the intra- and inter-test reliability, the dichotic consonant-vowel test was conducted within and between days. The single correct and double correct scores were calculated.

**Results** The analysis of the study showed good test-retest reliability for the single correct and double correct scores of the dichotic consonant-vowel test based on Cronbach's alpha values and Friedman's tests.

**Conclusion** This study's findings indicate that the dichotic test is a stable measure that can be clinically used for evaluation and can be used for research studies.

**Keywords** Dichotic listening, Single correct, Double correct, Reliability

## Background

Dichotic listening is a noninvasive technique for studying brain lateralization or hemispheric asymmetry. It is the most frequently particular extraction of the phonetic code from speech signal [1]. Dichotic tests can be used for testing selective attention if the examiner required response from only one ear [1]. Dichotic listening tasks were used in the audiological test battery to assess selective auditory attention, corpus callosum (interhemispheric transformation), maturation of auditory nervous, and auditory processing abilities in children and adults

concerning the hemispheric lateralization system [2–4]. A majority of individuals who are right handed reported right ear advantage (REA) of dichotic listening as when two different words are presented simultaneously, one to each ear, and most listeners perceive more of the right ear messages accurately compared to the nondominant left ear [5]. The possible reasons reported in the literature are the stronger and more enhanced contralateral auditory pathways than ipsilateral [6]. Therefore, the signals received and processed by the right side are faster within the left hemisphere and suppress the ipsilateral pathways of the signals to the left side ascending to the right hemisphere [7, 8]. There are various types of dichotic listening tasks applicable in dichotic listening tests, such as dichotic speech tests, consonant-vowel (CV) syllables, and monosyllabic words. The most commonly used is the dichotic consonant-vowel syllables paradigm. This test is used extensively in assessing functions and dysfunction

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in the temporal lobe and frontal lobe function, attention and information processing, and stimulus processing speed, in addition to being a measure of hemispheric asymmetry. The dichotic CV test is also reported to be applicable in identifying phonological processing and decoding problems and language impairment [9, 10].

Test-retest reliability refers to a test's consistency when administered multiple times. In other words, the results of the test must be similar if the test is evaluated at different times or days. The performance of dichotic listening tasks is majorly influenced by various factors, including subject related such as participants' attention, cerebral dominances, working memory, gender, ear advantage, top-down and bottom-up factors, and stimulus-related factor such as time lag in the stimulus presentations. These influencing factors reported in the previous studies indicated the need for reliability in the test paradigm [9–11]. Reliability can be measured in two ways: intra-day and inter-day. Previous studies have reported the test-retest reliability of the dichotic CV syllables paradigm in adults and found with a reliability correlation of about 0.86 [11]. Literature also showed good test-retest reliability in healthy children and older adults in specific conditions such as attentional manipulations [11–14]. In addition, studies also reported good reliability for dichotic tests in clinical populations such as individuals with learning difficulties and Alzheimer's disease [15–17]. However, these studies have not determined the intra- and inter-test reliability of the dichotic CV test; rather, it was measured in different attention conditions such as free recall, forced right, and forced left. In addition, larger sample sizes are needed concerning the generalization, as recommended in the previous studies [12–17]. The double correct and single correct scores of right and left were also checked for reliability. Furthermore, literature has shown the effect of aging on binaural integration ability using different dichotic listening tests which stated that younger adult scores were better as compared to older adults [18–20]. Hence, in the present study, only younger adults were included. Dichotic listening tests have also been developed in various languages [21–27]. In India, the test developed by Yathiraj (1999) [28] for dichotic CV is the widely used to assess the binaural integration skills in diagnostic auditory processing disorder test battery [29, 30]. However, literature shows that language might influence the perception of the dichotic CV stimuli in Tamil-speaking population [31, 32]. Although earlier studies of test-retest reliability of dichotic tests across have reported in various languages in adults and children [11–17], according to our knowledge, the literature does not explore intra- and inter-test reliability in Tamil-speaking younger adults. Furthermore, measuring the test scores within and across days

is essential to derive more efficient results about the reliability of the test in younger adults. Hence, the present study aims to measure the test-retest reliability of the dichotic listening test in Tamil-speaking younger adults with normal hearing. The objectives are to measure the intra-test reliability by administering the test within a day. Additionally, the inter-test reliability was measured by administering the test between the days.

## Methods

### Ethical approval and consent to participate

#### *Compliance with ethical guidelines*

In the current study, all of the testing procedures were accomplished using a noninvasive technique and adhered to the conditions of the institutional ethical approval committee. The institutional ethical approval committee approved the current study (HCC/ERB/EC/PB-01/2023–2024). The test procedures were clearly explained to the participants before testing.

#### *Consent to participate*

Written informed consent is taken prior commencing the data collection.

#### *Study participants*

A total of sixty right-handed female adults aged between 18 and 25 years participated in the present study. All the young adults were native speakers of the tamil language. The inclusion criteria were individuals with normal peripheral hearing, no significant history or complaint of any relevant external, middle ear disorders, neurological symptoms, intake of ototoxic drugs, exposure to loud sounds, and family history of hearing loss.

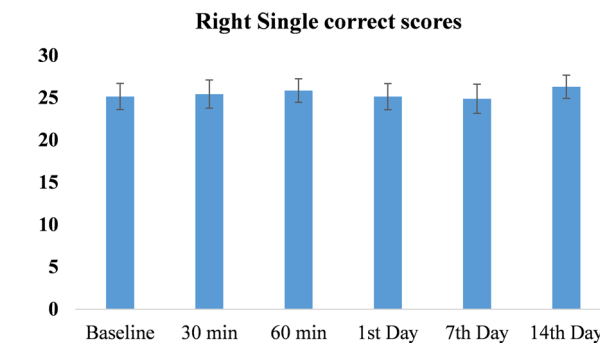
#### *Screening procedures*

A detailed case history was obtained from all the participants to rule out otological problems such as hearing loss. Pure-tone audiometry was done to determine the participants' hearing sensitivity. The air conduction thresholds, bone conduction thresholds, speech recognition thresholds, and speech identification scores were determined using a calibrated clinical audiometer (Inventis Padova, Italy) with Telephonics Dynamic Headphones 39 earphones enclosed in MX-41/AR supra-aural ear cushions and Radio Ear B-71 bone vibrator transducers. Immittance evaluation was carried out using a calibrated Inventis Clarinet (Inventis Padova, Italy) middle ear analyzer to identify the middle ear function. Transient-evoked otoacoustic emission measurements were recorded from both ears using the Intelligent Hearing Systems Duet (IHS, Miami, FL, USA). All included subjects had pure-tone audiometry threshold within normal limits (less than 15 dBHL) for air conduction (AC) and

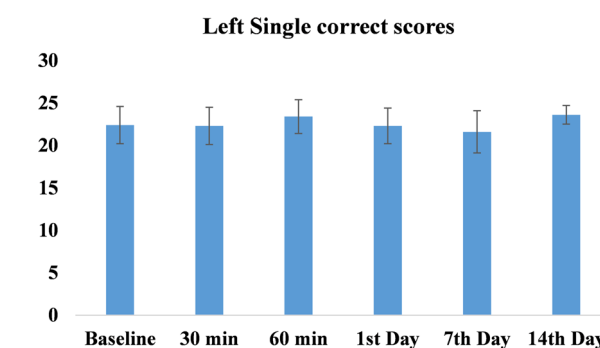
bone conduction (BC). Threshold determination was obtained using modified Hughson-Westlake technique in both ears [33]. Tympanogram was recorded using a probe tone of 226 Hz and acoustic reflexes at 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz. Bilateral “A”-type tympanogram with both ipsilateral and contralateral acoustic reflexes is present at 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz [34, 35]. Transient-evoked otoacoustic emissions (TEOAEs) were recorded using the calibrated “Intelligent Hearing Systems Duet” (IHS, Miami, FL, USA). Transient-evoked otoacoustic emission was recorded for the frequencies 1000 to 4000 Hz. The click stimuli were presented at 85 dB SPL. Transient-evoked otoacoustic emission was considered as present based on the criteria of 80% reproducibility and +6-dB signal-to-noise ratio (SNR) at any three consecutive frequencies [36, 37]. Screening Checklist for Auditory Processing in Adults (SCAP-A) developed by Vaidyanath and Yathiraj (2014) [38] was administered to the adults. This checklist has 12 questions related to auditory separation/closure, as well as memory and attention. It is scored on a 2-point rating scale (yes/no). Participants who scored less than 50% ( $< 6/12$ ) were included for the study (passed SCAP-A). All the participants met the above inclusion criteria and underwent further evaluation. All the testing procedures were done using a standard protocol in an acoustically treated room, and the permissible noise level of the room was as per ANSI/ASA S3.1-199 (R2013) standards [39].

### Procedure

The dichotic-consonant-vowel (CV) test was administered based on the procedure by Yathiraj (1999) [28] via a laptop calibrated with TDH-39 supraaural headphones. The stimulus consisted of six syllables (/pa/, /ba/, /ta/, /da/, /ka/, /ga/) and was presented at 50-dB SL (ref. SRT) to both ears simultaneously with 0-msec lag between them. The test was administered in a free recall condition. The participants were asked to repeat or write down the CV syllables in the regardless of the sequence. Prior to the real testing, the participants were provided with practice items to ensure that they understood the instructions. The responses were noted on a response sheet, and the scores were calculated as double correct (DCS), single correct left (SCL), and single correct right (SCR). The test was conducted within and between days. The within-day procedure was done by performing the dichotic CV testing three times, including a baseline, at 30 min and 60 min. The between-day tests were conducted on the 1st, 7th, and 14th days. The time interval of intra- and inter-testing was chosen based on the previous studies of test-retest reliability on various behavioral tests of auditory



**Fig. 1** Mean and standard deviation of right single correct DCV scores across the session



**Fig. 2** Mean and standard deviation of left single correct DCV scores across the session

processing disorder (APD) [17, 40–42]. Statistical analyses compared the data.

### Data analysis

IBM SPSS (Statistical Package for the Social Sciences) Statistics version 21.0 was used for data analysis. Shapiro-Wilk test of normality was implemented to determine if the data were normally distributed or not. Hence, non-parametric inferential statistics were done to analyze the data since the data were not normally distributed.

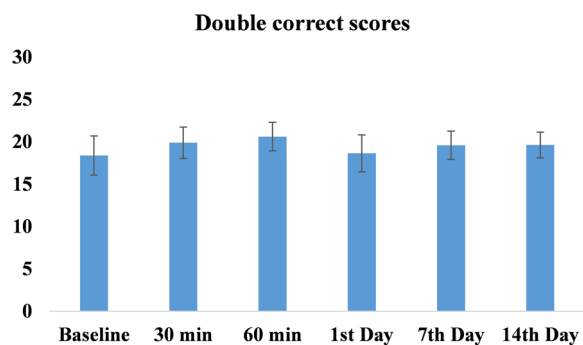
### Results

A descriptive statistical analysis of the data was done to determine the mean and standard deviation of right, left, and double correct scores across the sessions. The scores were similar across the sessions. The mean and standard deviation of the right single correct DCV scores across the session are shown in Fig. 1.

The mean and standard deviation of left single correct DCV scores across the session are shown in Fig. 2.

The mean and standard deviation of double correct DCV scores across the session is shown in Fig. 3.

In addition, nonparametric Friedman tests were done to determine if the scores were different for intra-test



**Fig. 3** Mean and standard deviation of double correct DCV scores across the session

and inter-test DCV scores. The results of Friedman’s test showed that there was no significant difference in right SCS, left SCS, and DCS for intra-test and inter-test measurements. The results of Friedman’s test are shown in Table 1.

The test-retest reliability was determined using Cronbach’s alpha test. The results demonstrated that the alpha values for the DCV right, left, and double correct scores across sessions were 0.64–0.68, 0.65–0.69, and 0.85–0.89, respectively. The result shows good test-retest reliability for the DCV scores across the sessions. The results of Cronbach’s alpha are shown in Table 2.

**Discussion**

The purpose of the present study was to measure the test and retest reliability of the dichotic listening test within and across days within the same participants. The present study results reported no variability observed across different repeated measures. The results of Cronbach’s alpha showed that the alpha values were between 0.64 and 0.89 for DCV scores. The study results agree with previous studies carried out in children and older adults using different dichotic listening paradigms, showing the correlation coefficient values which were between 0.7 and 0.93 [43, 44]. A similar study was conducted on children with normal hearing using dichotic CV paradigm, which also reported that the DCV scores were maintained after

**Table 1** Result of Friedman test for comparison of DCV scores across sessions

DCV scores	$\chi^2$	Degree of freedom	Significance value
R-SCS	1.14	5	$p > 0.05$
L-SCS	2.13	5	$p > 0.05$
DCS	0.96	5	$p > 0.05$

**Table 2** Cronbach alpha values of right, left, and double correct DCV scores across sessions

DCV scores	Intra-session	Intersession	Overall
R-SCS	0.68	0.64	0.65
L-SCS	0.69	0.65	0.68
DCS	0.89	0.85	0.86

1 year of testing [45]. Studies have reported excellent test and retest reliability of the DCV test paradigm in older adults with normal hearing about 2 weeks apart without any significant variability [11, 14]. This indicates that the repeatability is independent of the time intervals across testing after 2 weeks of testing [11]. In addition, the correlation coefficient was 0.61–0.86 [11]. Recent literature also indicates good test-retest reliability of the dichotic test in healthy children. They stated that there were no significant changes in mean scores of dichotic CV syllables on repeated test administration on the same children. Furthermore, they stated that dichotic test scores might increase as the number of test items increased. This led to yield more reliable results [14, 17]. On the other hand, studies also showed good retest reliability of dichotic listening tests in clinical populations such as the Alzheimer’s group and children with learning difficulties [15–17]. Additionally, good test-retest reliability was also observed for randomized dichotic digits tests in younger adults [17, 46]. Also, right ear scores were significantly higher as compared to left ear scores for adults, children, and clinical population as well. From the abovementioned studies, our study findings are in consensus with previous studies [11, 14, 15, 17, 46]. According to our knowledge, this is one of the first studies that showed good reliability even for single correct scores and double correct scores. Thus, administering this test on young adults multiple times within a day and also across days is possible without affecting the scores. Therefore, the results of the study suggest that dichotic CV has good intra- and inter-test-retest reliability for double and single correct scores.

**Conclusion**

The study attempted to determine the intra and inter-test reliability of the dichotic CV test. It was determined in young adults with normal hearing sensitivity. The study’s results showed a good test-retest reliability for intra- and inter-test measurements. The reliability was good for double correct scores and single correct scores. Thus, the study highlights that dichotic CV can be used reliably for clinical and research applications.

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**Authors' contributions**

SR, BK, RR, AK, and AM involved in study design, acquisition of data, drafting the manuscript, and interpretation of the results; KK, involved in study design, acquisition of data, supervision, drafting the manuscript, and critical revision of the manuscript; and PP involved in study design, supervision, critical revision of the manuscript, and statistical analysis.

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None to declare.

**Availability of data and materials**

Not applicable.

**Declarations****Ethics approval and consent to participate**

In the current study, all of the testing procedures were accomplished using a non-invasive technique and adhered to the conditions of the institutional ethical approval committee. The institutional ethical approval committee approved the current study Holy Cross College Ethical Committee (HCC EC) Reference No: (HCC/ERB/EC/PB-01/2023-2024). The test procedures were clearly explained to the participants before testing. Consent to participate: The participants gave written informed consent prior to commencing the data collection.

**Consent for publication**

The participants gave written informed consent for the publication of the data and materials contained within this study.

**Competing interests**

The authors declare that they have no competing interests.

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