

Does the Type of Transducer Influence Digit Span Test for Assessing Short-term Memory?

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ABSTRACT

Introduction: Digit span is the most widely used to measure the capacity of auditory working memory and administered using two different variants forward digit span and backward digit span test. It was revealed that auditory digit span test is influenced by various extrinsic factors and intrinsic factors, such as rhythm of presentation, language, the material used, method of scoring, rate of presentation, live voice testing, age, sex, race, and pathological condition; however, the mode of stimulus presentation on auditory digit span test was not studied previously.

Aim: Hence, in the present study, it is attempted to find out the type of transducer influences digit span test for assessing short-term memory.

Methods: A total number of 44 normal hearing participants within the age range of 18–25 years were included in this study. Auditory digits span testing, that is, forward and backward were done by using calibrated headphone and loudspeaker in soundproof room.

Results: The results showed no significant differences for both forward (Z -score = 3.692, $p > 0.05$) and backward digit span test (Z -score = 3.712, $p > 0.05$) between headphone and loudspeaker.

Conclusion: Auditory digit span test is not influenced by types of transducers. Hence, loudspeaker can be used alternatively for easy and convenient way to test auditory working memory especially for difficult-to-test population and children clinically and aural rehabilitation.

Keywords: Auditory, Digit span, Short-term memory, Transducer, Working memory.

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INTRODUCTION

Working memory denotes the ability to retain stimuli and allows the temporary storage of relevant information.^{1,2} Digit span test is one of short-term memory test to evaluate cognitive status.^{3,4} There are two types of digit span test, that is, forward and backward digit span tests which are most widely used test for the short-term working memory (STM).⁵ Short-term memory helps the individual to retain, follow, and integrate the stream of auditory information which is considered an important factor contributing to receptive speech development, auditory processing, auditory perception, and other higher cortical functions, such as intelligence, cognition, and attention.^{6,7} In forward digit span test, the digits are recalled in the same order, whereas in backward digit span, the digits are recalled in the reverse order.⁴ Traditional digit span testing was influenced by two factors. First, the examiner's variation in loudness, rate, pitch, emphasis, and clarity of digit, and second, the variation in clarity between different examiners.^{8,9} It was also reported that the digit span test is also affected by the rate of presentation between two-digits, duration of digit which is called the administrative error⁴ and hormonal changes.¹⁰ Hence, an accurate recorded stimulus should be presented randomly through computer for digit span test.⁴ Previous researches also suggested that substantial variability influence the result of auditory digit span test.^{7,4} Hence, it may be assumed that forward and backward digit span tests may also be influenced by the use of transducer, that is, headphone and loudspeaker. Hence, it is necessary to study the effect of transducer on auditory digit span test.

METHODS

A total 44 number of participants were included in this study with the age range of 18–25 years (Mean age – 20.9 years, SD – 0.9).

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Participants in this study had no any otological and medical-related issues, no neurological abnormalities, and no history of using alcohol and steroid. All participants had thresholds of pure tone audiometry within 15 dBHL at octave frequencies from 250 Hz to 8000 Hz as per Goodman's classification for degree of hearing loss,¹¹ Speech recognition threshold of up to 25 dBHL, and speech identification of monosyllables of at least 88%¹² with "A" type tympanogram^{13,14} and normal acoustic reflex threshold ranging from 85 dB SPL to 100 dB SPL at the octave frequencies 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz ipsilateral and contralateral in both ears.¹⁵ Auditory digit span testing was done using APEX 3 software using calibrated headphone (TDH 39) and loudspeaker (ALPS) in soundproof room. The order of transducer presentation and order of forward and backward digit span test were alternated between headphone and loudspeaker to avoid order effect. At least 30 min gap had been given to avoid learning effect to each participant. All testing were done in sound-treated room and consent form was taken from each participant before testing.

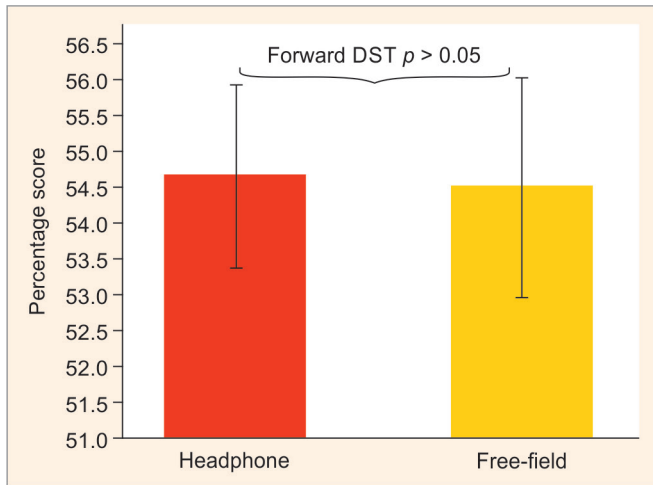


Fig. 1: Indicate mean and standard deviation of forward DST headphone and loudspeaker

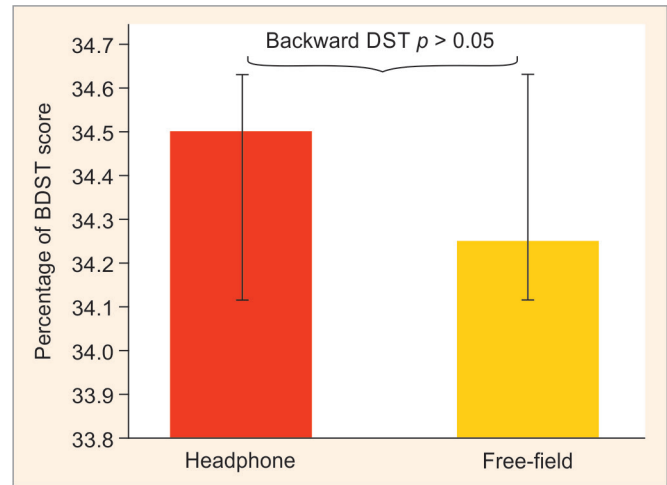


Fig. 2: Indicates mean and standard deviation of backward DST headphone and loudspeaker

Auditory Digit Span Test

Forward and backward digit span tests were used to assess auditory working memory. Total seven lists were prepared with increasing level of difficulty by using digit one to nine as stimulus, that is, list 1 record with three cluster numbers, list 2 with four cluster numbers, and likewise list 7 contained nine clusters of numbers. List 1 included two subsets whereas list 2 to list 7 included three subsets. All lists were recorded using male voice with inter-stimulus intervals. Stimulus was presented through headphone and loudspeaker using APEX 3 software. Each participant was instructed to listen and type digit in sequential order for forward digit span test and in reverse order for the backward digit span test. For each correct response 5% score was given. Auditory working memory was calculated in the total percentage of respondents for cluster of numbers correctly identified for both forward and backward digit span test.

Statistical Analysis

Descriptive analysis and paired *t*-test were used for statistical analysis of the present study.

RESULTS

The result of the current study shows that there is no significant difference between both the transducers for forward as well as backward digit span tests.

Figure 1 shows the mean and standard deviation of the forward digit span test between headphone and loudspeaker. From Figure 1, it can be seen that there is very less difference in mean and standard deviation between two transducers. A paired sample *Z*-test shows no significant difference between headphone and loudspeaker in forward digit span test ($Z = 3.692, p > 0.05$).

The mean and standard deviation of the backward digit span test between headphone and loudspeaker is shown in Figure 2. Figure 2 shows that there is very less difference in the mean and standard deviation between two transducers. A paired sample *Z*-test also shows no significant difference between headphone and loudspeaker in backward digit span test ($Z = 3.712, p > 0.05$).

DISCUSSION

The main purpose of the present study was to see the effect of transducers used for auditory working memory test. In the current

study, the examiner administrated computer-controlled and randomized presentation of recorded digit (forward and backward) were used to test the auditory working memory or short-term memory. Previous studies also suggested that auditory digit span test is used to test short-term memory and computerized tests of digit span should be used clinically than traditional paper and pencil digit span test.⁴ The examiner administrated computer-controlled digit span test has significantly enhanced the test-retest reliability and precision of this test for assessment.⁴ The mean differences also found between forward and backward digit span scores in free-field condition and forward digit span score was better than backward digit span score test. The same findings were also found in headphone condition. In the previous studies also, it has been reported that the auditory working memory was better for forward digit span test than the backward digit span test¹⁶ In the previous literatures, the computerized-based digit span testing was done using headphone and dearth of studies are available to suggest the use of loudspeaker for auditory digit span test. Previous study also reported that the presentation mode of stimulus may influence the various audiological testing. Hence, in the present study, headphone and loudspeaker were used to see the effect of transducer in forward and backward digit span tests which is one of the testing method variables that may influence the test result findings. Thus, the present study provides information regarding the use of either headphone or loudspeaker as benchmark for the selection of transducer during digit span test.

LIMITATIONS OF THE STUDY AND FUTURE DIRECTION

The present study was carried out with a less sample size. Hence, large sample size is essential for better generalization of present research findings. In addition, the result of the study was limited to only adult in age group 18–25 years. Future studies can consider different age group to verify the obtained result of present study.

CONCLUSION

The study found that auditory digit span test was not influenced by types of transducers. The findings of the present study suggest that loudspeaker can be used alternatively for easy and convenient

way to test or considering training of short-term memory especially for children and difficult-to-test population clinically and aural rehabilitation. It is also beneficial for clinicians to recognize factors that influence outcomes of digit span test.

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