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Research Paper

Sensory Modalities and Other Factors Affecting Scoring of Digit Span Test

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ABSTRACT

Working memory (WM) is the process of keeping information for a short period of time. WM refers to a brain system that provides temporary storage for complex cognitive task. The working memory capacity is limited and it performs both the functions of memory and processing for a short duration of time (Baddeley, 2012). WM serves as an interface between perception, long term memory and action. Despite physical absence of sensory input, a representation of the information can be maintained over a period of time (Baddely, 2012). There are a lot of tests available to determine working memory capacity. Digit span test is one of the easily accessible tests to detect WM. Wechsler's Digit span test consist of two subtests. One is digit forward test and another is digit back word test. In this test the examiner asked the participant to repeat increasing span of digit in forward manner for digit span forward test and in reverse manner for backward test. The length of digit increases in each line. For each trial in forward and backward digit span test, a correct response will score as 1 and incorrect score will be marked as 0. The item score is the sum of the score in two trials. The maximum score in each sub test will be 16. ***Aim of the study***: The main aim is to evaluate the possible factors affecting the result of digit span test. ***Procedure and Result:*** Digit span test was carried out in audio only modalities by using audiometer in a sound treated chamber. DST in both audio-visual modalities was carried out using software in video format. After completing the DST, we continue pure tone audiometry test to find out the relationship between age, hearing abilities with working memory. From this study we found that hearing loss, age have negative correlation with scoring of DST in both of these modalities.

Keywords: *Digit Span Test, Hearing Loss, Auditory Working Memory, Presbicusis, Cognition, Cognition Test*

Working memory (WM) is the process of keeping information for a short period of time. WM refers to a brain system that provides temporary storage for complex cognitive task. The working memory capacity is limited and it performs both the

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functions of memory and processing for a short duration of time (Baddeley, 2012). It has application in all human activities including speech perception (Baddeley, 2003). Although various mechanism of the complex interaction of cognition have been hypothesized (c.f. Nixon et.al., 2019; Pichora-Fuller & Singh, 2006), these complex interaction of cognition and speech understanding has been very lucidly described in the Ease of Language Understanding model (ELU; Rönnberg, 2003; Rönnberg et.al., 2010, 2013, 2016, 2019). This model hypothesizes that either language understanding or speech recognition is effortless when the incoming stimuli matches with the stored representation of language in the memory system of an individual. However, in adverse listening conditions, such as in presence of background noise, reverberation, hearing loss, or co-existence of more than one difficult to-listen condition, cognitive resources are employed for speech understanding. In particular, the ELU model predicts that in unfavorable listening conditions, speech recognition essentially requires involvement of working memory and its central component, executive functions (Rönnberg et. al., 2016, 2018). WM serves as an interface between perception, long term memory and action. Despite physical absence of sensory input, a representation of the information can be maintained over a period of time (Baddely,2012).
There are a lot of tests available to determine working memory capacity. Digit span test is one of the easily accessible tests to detect WM.

Digit span test

Wechsler,s Digit span test consist of two subtests. One is digit forward test and another is digit back word test. In this test the examiner asked the participant to repeat increasing span of digit in forward manner for digit span forward test and in reverse manner for backward test. The length of digit increases in each line. For each trial in forward and backward digit span test, a correct response will score as 1 and incorrect score will be marked as 0. The item score is the sum of the score in two trials . The maximum score in each sub test will be 16.

Need of the study

For cognitive healthy adults with hearing loss, audiologists are less concerned with their listening processing as they already have intact language and cognitive skills. Thus, audiologists generally provide adequate and appropriate hearing technologies to make sound more accessible for these individuals. Several studies suggests that WM plays a key role in understanding speech (Pichora-Fuller et al., 1995; Wingfield and Stine-Morrow, 2000; Akeroyd, 2008) and also to predict performance on tasks including phonological processing (Classon, Rudner, & Ronnberg), and attention (Kane & Engle, 2003). Digit span test is mostly used to assess working memory capacity of patient. There are so many factors which affect the scoring of digit span test. For a proper evaluation of test we need to know about the factors which are affecting the results.

Aim of the study

The main aim is to evaluate the possible factors affecting the result of digit span test.

Objective

To conduct digit span test in auditory and visual modalities and to compare the scoring of these modalities. We carry out this test in presbicusis patients to find out the relations between working memory and hearing loss.

METHODOLOGY

We recruited 50 participants having age range (18-32), mean (21.42) and standard deviation 2.49 having normal hearing sensitivity in group 1. We also included 21 participants of age

range (50-74; mean: 62.29; SD: 4.9) having age related hearing loss. All the subjects have no previous history of any psychological or cognitive problem.

Procedure

A written consent for participation in the test was obtained from the subjects after they were explained about the study. They were informed to take small breaks whenever they desired in between the tests.

First pure tone audiometry test was carried out in a sound treated chamber to eliminate hearing loss in group 1 participants and to eliminate conductive hearing loss in participant of group 2. In pure tone audiometry test we conducted both air conduction and bone conduction tests. In group 2 participant we conducted tympanometry test to eliminate the middle ear pathology if any.

After completing these test we started conducting digit span test in auditory modalities only. We seated all the participants in a sound treated room. We started presenting digit in sequencing manner through the audiometer by using speech stimuli. The intensity of the signal was kept constant at 20 dB SL of PTA level for both group 1 and 2 participants. Each digit was presented at a constant manner of one digit per seconds. First forward digit span was carried out and after that backward digit test was carried out. The test procedure was same for each participant in this study.

Again, after a gap of 5 minutes we started applying digit span test in visual modalities. In visual modalities test the entire digit appears in a white back ground screen in a video format. In this test digit appears in the screen at a rate of one digit per second. The participant has to seat in front of laptop. Any patient having vision problem were allowed to wear corrective lenses during these tests. Only 7 participants of group 1 wore the corrective lenses during these tests.

Backward digit span test was carried out followed by forward digit span. Total test procedure completed within 45minutes of time.

RESULTS

We used SPSS software for data analysis. The mean value of forward digit span test in normal hearing by auditory modality was 11.50 (S.D 1.70; Range: 8-14) and visual modality was 8.70 (S.D 1.83; Range: 4-12). The mean backward digit span in auditory modality was 6.28 (S. D 2.09; Range:3-12) and in visual modalities mean was 5.62 (S. D 1.99; Range: 3-12). The mean pure tone average (PTA) for the young adults was 20 dB HL (*S.D*: 3.29; Range: 15-25 dB HL).

Table 1 shows the mean and the standard deviation of the younger adults' performance in the forward and backward digit span test by using two modalities.

Variables	Mean	Standard Deviation
Age	21.42	2.49
Forward DST Visual mode	8.70	1.83
Backward DST Visual Mode	5.62	1.99
Forward DST Auditory mode	11.50	1.70
Backward DST Auditory mode	6.28	2.09
Pure Tone Average	20	3.29

Table 1: Mean and standard deviation of digit span test in normal hearing populations.

The mean value of forward digit span test in elderly adult having hearing loss by auditory modality was 10.19 (S.D 1.66; Range:6 -12) and visual modality was 8.71 (S.D 1.95; Range: 4-12). The mean backward digit span in auditory modality was 5.86 (S.D 1.10; Range:4-8) and in visual modalities mean was 5.95 (S.D 1.39; Range: 3-8).The mean pure tone average (PTA) of both ear for the elder adults was 37.88 dB HL (*S.D*: 15.40; Range: 27.5-83.5 dB HL).

Table 2 shows the mean and the standard deviation of the elder adults' performance in the forward and backward digit span test by using two modalities.

Variables	Mean	Standard Deviation
Age	62.29	4.93
Forward DST Visual mode	8.71	1.95
Backward DST Visual mode	5.93	1.39
Forward DST Auditory mode	10.19	1.66
Backward DST Auditory mode	5.85	1.10
Pure Tone Average	37.88	15.40

Table 2: Mean and the standard deviation of the elder adults' performance in the forward and backward digit span test by using two modalities

We use Pearson Correlation test to find out the correlation between various variable. In elder adult having hearing loss; age is negatively correlated with forward digit span test using auditory *(r= -0.68*, p< 0.01) and visual modality (*r= -0.73*, p< 0.01). Age is also negatively correlated with backward digit span test using auditory modality (r= -0.46, p< 0.01) and visual modality (r= - 0.60, p<0.01). Pure tone average is negatively correlated with forward digit span test (r= -0.64, p<0.01) by using both auditory and (r= -0.72, p< 0.01) visual modality respectively. Here we also found the statistically significant correlation in backward digit span in auditory modality (r= - 0.47, p < 0.01) and visual modality (r=-0.64, p<0.01).

Table 3: Correlation between PTA, Age with Forward and Backward DST by using both modalities.

	Forward DST Visual mode	Backward DST Visual mode	Forward DST Auditory mode	Backward DST Auditory mode
Age	-0.73**	-0.60**	-0.68**	-0.46**
PTA	-0.64**	-0.45**	-0.72**	-0.47**

** Correlation is significant at the 0.01 level (2-tailed)

DISCUSSION

Digit span test is a test for working memory. The digit span test is a very short test that diagnoses cognitive abilities of person. It is frequently used in hospitals and physicians' offices in order for a clinician to quickly evaluate whether a patient's cognitive abilities are normal or impaired. From this study we found greater digit span test result in auditory modality in compare to visual modality. As we know digit span test are mainly used for auditory memory test, we did not find any improve score when we used visual mode of presentation in both forward and backward digit span test (DST). We got better result when digits were presented through auditory modality.

Age is another factor which affects the scoring of DST. In this study we did not find any correlation of age and DST in younger adult. That may be due to the limited age range we took in our study. But in older adult we found a strong correlation of age and DST in both of the modalities. We found a decreasing digit span score with increasing age.

Working memory is somewhat affected due to the hearing loss of patients. In this study we also found negative correlation of hearing loss and digit span score in both modalities.

With increasing degree of hearing loss, we found a decreased score of digit span test. We did not find any correlation of scoring and gender. But found a significant difference in educated and uneducated people in our study. Educated people have a high scoring in DST compare to uneducated people in older adult population. In younger adults we did not took any uneducated person for this study.

CONCLUSION

We should consider these above factors when we use the digit span test. Age, Hearing loss, Education level generally affect the scoring of digit span test. As digit span test is a auditory memory test we should use auditory modality for scoring. If Auditory Working Memory Capacity has the potential to influence speech processing ability and apparently the amplification, then it seems admissible that the Audiologists may seek ways to assess AWM in the clinical setting.

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Conflict of Interest

The author(s) declared no conflict of interest.

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