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Development of an Auditory Sustained Attention Test Based on Simple Mental Calculations: Preliminary Findings

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Abstract

The Auditory Sustained Attention Test (ASAT) is a measure of sustained auditory attention and concentration. The test is composed of 50 independent auditory stimuli in the form of simple addition operations. Validity of the measure is supported by providing a set correlation coefficients with some criterion measures.

Keywords

Auditory sustained attention, working memory, simple mental calculations, intelligence

1 | Introduction

1.1 | Description of the Test

The Auditory Sustained Attention Test (ASAT; Nadri, 2018) is a mental calculation test to measure sustained auditory attention and concentration. The auditory stimulus contains 50 items in which two simple addition operations are presented (like 2 + 3; 1 + 4). Examinees have to add up the results of both operations and write down the answer on the answer sheet. Computations should be done without the use of a pen and paper. The time interval between the presentations of the two operations within the item is 1 second and between items is 3 seconds. The test runs for five minutes which is the minimum duration to test sustained attention (Broadbent, 1971). In order to minimize the computational load of the task, the digits were limited between 1 and 5 and only addition operation was used. The Cronbach's alpha reliability coefficient of the test, considering each pair of operations as an item, was 0.91.

1.2 | Theoretical Underpinnings

The ability to give focused attention to a task without deflection is central to various cognitive functioning. Deficits in attention are symptoms of several disorders in individuals with acquired brain injury (Sohlber & Mateer, 2001) and other disorders including schizophrenia and metabolic disturbances (Mirsky et al., 1991). Furthermore, affective and anxiety disorders such as depression and bipolar disorder coincide with impairments of attention.

Mirsky et al. (1991) proposed the multicomponent model of attentional processes which includes three elements of focus, sustain, and shift. *Focus* refers to the ability to select target information when competing irrelevant stimuli are present

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(selective attention). *Sustain* or *vigilance* component of the model refers to the ability to maintain attention on a task for an extended period of time. The ability to remain focused on a task (sustained attention) decline with time. Neuropsychological studies of sustained attention have demonstrated that this component of attentional process is related to the frontal lobe of the brain (Witkin et al., 1987). Patients with lesions in the frontal lobe had more difficulty than patients with posterior lesions in vigilance tasks (Witkin et al., 1987). Finally, *Shift* is the ability to change attentive focus from one task to another (cognitive flexibility or cognitive shifting).

Sustained attention is closely related to working memory. Neuroimaging studies have indicated that the prefrontal cortex function (PFC) is disturbed in patients with schizophrenia. Sustained attention and the executive function of the working memory are located in the prefrontal cortex and both are impaired in schizophrenia patients (Silver & Feldman, 2005). Sliver and Feldman (2005) show that working memory and sustained attention are correlated in a group of schizophrenia patients. They argue that the common localization of sustained attention and working memory suggest that they share the same neural mechanism and are, therefore, linked.

Sohlber and Mateer (2001) also state that sustained attention has two components: vigilance and working memory. Apart from the ability to keep attending to continuous or repetitive tasks (vigilance) sustained attention also subsumes working memory, i.e., the ability to hold and work with information in the mind. In the Attention Process Training Program (APTP; Sohlberg & Mateer, 2001), a rehabilitation program to reduce the attention deficits of patients with brain injury, there is emphasis on working memory tasks. There are mental math activities among the tasks designed to improve sustained attention in the APTP. Therefore, we used mental arithmetic tasks to develop an auditory sustained attention test. Mental calculation tasks are typical tasks to measure working memory (Lynn & Irwing, 2008) because "the solution of a complex mental arithmetic problem requires one to perform one calculation, hold the result of that calculation in memory while performing new calculations, and then combine the results of all necessary calculations to provide an answer" (Mackintosh & Bennett, 2003, p. 520).

In the ASAT, 50 simple mental calculation items were developed. Each item contained two simple math operations like 2+3 and 4+5. Items were recorded on an audio CD and presented orally. The time laps between each operation within items was 1 second and across independent items was 3 seconds. To minimize the computational load, only addition operation and numbers 1 to 5 were used. To tap sustained attention, i.e., the ability to remain focused on a task, the test ran for five minutes, the minimum time to measure sustained attention (Broadbent, 1971). As stated above, Sohlber and Mateer (2001) argue that sustained attention includes vigilance and working memory. The mental arithmetic task is an accepted measure of working memory which is also included in the Wechsler's Adult Intelligence Scale (Wechsler, 2008). By running the test for an extended period of time, the vigilance component of sustained attention is also measured.

2 | Method

2.1 | Participants

A total of 97 English as a foreign language (EFL) undergraduate students at Islamic Azad University of Mashhad, Iran, participated in the study. Of the total sample, 78 students were female and 19 were male. Students' age ranged from 19 to 52 (mean age = 24.26 years, *SD* = 5.647).

2.2 | Instruments

2.2.1 | Listening Comprehension (LC) Test

The Preliminary English Test of the Cambridge Assessment English is an intermediate level test to measures basic knowledge of English as a second language. The listening comprehension section of one of the past papers of the Preliminary English Test was employed to assess the participants' listening comprehension ability. The Cronbach's reliability for the listening scores in this study was 0.79.

2.2.2 | The d2 Test of Attention

The d2 test (Brickenkamp & Zillmer, 1998) is a practical measure of attention and concentration processes which includes the simultaneous presentation of visually similar stimuli. In this test candidates should cancel out "d's" (target symbol) with two dashes above or below them in 20s for each of the 17 rows of characters. The total number of characters canceled is considered a measure of processing speed and the total number of characters correctly cancelled minus errors (concentration performance) is a measure of attention. These two scores were used in this study as criteria. The Cronbach's reliability index for the speed score was 0.93 and for the concentration score was 0.97.

2.2.3 | Raven's Standard Progressive Matrices

Mental ability and abstract reasoning (fluid intelligence) were assessed by the Raven's Standard Progressive Matrices (RSPM; Raven, 2000). Since the original Raven's test is relatively long, Bilker et al. (2012) developed a short 9-item and a 12-item version of the test which are the best predictors of the full RSPM. In this study, the 12-item version of the test was employed. The Cronbach's reliability index for the scores was 0.65 in this study.

2.2.4 | Persian Adaptation of Baddeley's 3-min Grammatical Reasoning Test

Baghaei et al. (2017) adapted Baddeley's (1968) 3-min grammatical reasoning test for the Persian language by using the verbs "inscribe" and "circumscribe" and the shapes of a square inside a circle and a circle inside a square. Respondents have to mark whether the statements correctly describe the position of the square and the circle. Baghaei et al. (2017) demonstrated the validity and reliability of the Persian adaptation of the test. The Cronbach's alpha reliability index for the grammatical reasoning test scores was 0.93 in this study.

2.2.5 | The Ruff 2 & 7 Selective Attention Test

Sustained and selective aspects of visual attention were measured by Ruff 2 & 7 test (Ruff et al., 1992). Ruff 2 & 7 is a paper-and-pencil test which includes a set of 20 blocks of characters in which the target items (2 and 7) are semi randomly distributed among distractors (letters). Participants are asked to cross out as many targets (2 and 7) as possible in a given period of time, while ignoring irrelevant numbers and letters. After 15s, test leaders notify examinees to start with the next block. The Chronbach's alpha reliability for Ruff 2 & 7 test was 0.92 in this study.

3 | Results and Conclusion

Table 1 shows the correlation coefficients between the ASAT and the criterion measures (Nadri et al., 2019). As the table shows, ASAT moderately correlates with the criterion measures. Specifically, the correlations between ASAT and d2 and Ruff 2 & 7 are of note. As explained earlier, d2 and Ruff 2 & 7 tests are two measures of attention and concentration. The significant and moderate correlations between ASAT and these two measures can be considered as validity evidence for the ASAT. However, these correlations are smaller than the correlations between the two d2 scores and Ruff 2 & 7 scores. This is obviously due to the differences in the nature of these tests. While d2 and Ruff 2 & 7 are both visual cancelation tests, the ASAT is based on mental calculations through auditory channel. Therefore, it is not surprising that the d2 and Ruff 2 & 7 have a higher correlation with each other than with the ASAT. As one reviewer noted, the ASAT could be a measure of working memory as test takers have to hold the results of two operations in their memory and compute the sum. As explained earlier, working memory is a component of sustained attention. By keeping the information to be held in memory short and extending the time, we aimed to measure sustained attention. The current study provides some preliminary findings concerning the validity of ASAT. Future studies should have a closer look at the validity of ASAT as a measure of auditory sustained attention or working memory. Associations between ASAT and tests specifically developed to measure auditory sustained attention and working memory should be examined. Furthermore, the influence of test length on the

validity indices is also a major issue to examine. Perhaps running the tests for longer periods of time (e.g. 8-10 mins) might better tap the construct of auditory sustained attention.

Table 1

Matrix of Correlations between the Measures

	Ruff 2 & 7	Listening Comprehension Test	S.P. (d2)	C.P. (d2)	3-min Grammatical Reasoning Test	RSPM	ASAT
Ruff 2 & 7	1	0.30**	0.49**	0.56**	0.35**	0.35**	0.33**
Listening Comprehension Test		1	0.29**	0.35**	0.26**	0.16	0.21*
S.P. (d2)			1	0.93**	0.25*	0.29**	0.33**
C.P. (d2)			.	1	0.27**	0.38**	0.41**
3-min Grammatical Reasoning Test					1	0.27**	0.27**
RSPM						1	0.34**
ASAT							1

Note. SP = Speed of Processing of d2; CP = Concentration Performance of d2; RSPM = Raven's Standard Progressive Matrices; ASAT= Auditory Sustained Attention Test

*$p < .05$, **$p < 0.01$, $n = 97$

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Conflict of Interest

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Data Availability Statements

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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