



## Original Article

## A Computer-Based Sustained Visual Attention Test for Pre-School Children: Design, Development and Psychometric Properties

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### ABSTRACT

**Background:** Sustained visual attention is a prerequisite for learning and memory. The early evaluation of attention in childhood is essential for their school and career success in the future. The aim of this study was to design, development and investigation of psychometric properties (content, face and convergent validity and test-retest and internal consistency reliability) of the computer - based sustained visual attention test (SuVAT) for healthy preschool children aged 4-6 with their special needs.

**Methods:** This study was carried out in two stages: in the first stage computer-based SuVAT in two versions original and parallel were developed. Then the test-retest and internal consistency reliability using intra-class correlation and Cronbach's alpha coefficients respectively were examined; Face validity was calculated through ideas gathering from 10 preschool children and content validity evaluated using CVI and CVR method and convergent validity of SuVAT with CPT was assessed using Pearson correlation.

**Results:** The developed test showed a good content and faces validity, and also had excellent test-retest reliability. In addition, the assessment of internal consistency indicated the high internal consistency of the test (Cronbach's alpha=0.869). SuVAT and CPT test demonstrated a positive correlation upon the convergent validity testing.

**Conclusion:** SuVAT with good reliability and validity could be used as an acceptable sustained attention assessment in preschool children.

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### Introduction

Attention is defined as “taking possession of the mind in clear and vivid form, of one out of what may seem several simultaneously possible objects or trains of thoughts. It implies withdrawal from some things in order to deal effectively with others” [1]. Attention, working memory, and inhibitory control are three important components for early school success [2] and the ability to sustain attention for a long time in order to accomplish a task

can be a predictor of a child's future' success [3]. Based on several attention models, different classification of attention are available [4] which one of the most important types of attention with a significant role in learning and in enhancing the school achievement is sustained attention [5]. Sustained attention is defined as a basic function of attention that is of particular importance to a child's ability in order to maintain attention and focus on a specific stimulus [6].

It is well known that sustained attention deficit is in wide spectrum such as Attention Deficit Hyperactivity Disorder (ADHD), pervasive developmental disorder, conduct disorder, mood and anxiety disorders, and psychotic symptom [6]. Furthermore, this impairment causes

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serious problems for child in adulthood which include: cognitive dysfunction [7], poor school performance [8], adult mortality [9], worse social communications [10,11], high potential for addiction [12], high-risk behaviors [13], occupational impairments [14] and similar attention problems. Since attention problems are common among preschool children [5], therefore the early evaluation of attention in preschool children is crucial.

In the field of neuropsychological assessment of attention, three types of tests were used: function-based tests, rating scale (teacher, parents, and the child), and structured interviews [15]. Function-based tests were designed to examine and identify the salient features of sustain, selective, focus, and divided attention as well as attention span [6]. Connors' Continuous Performance Test (CPT) [16] is one of the function-based tests used for the evaluation of sustained attention although it is excessively long and boring for kids and also needs letter identification which is meaningless for preschool children. However, the two main profits of computer-based assessments in kids are scoring promptly which are competent to keep proper record of commission and omission errors and also accurate responses beside the reaction time in order to the achieve to trends of the effectiveness of interventions and an interpretive profile based on the normative data [17], in the other view, it seems they are quite interesting for kids and their motivation to have more cooperation and participation during the evaluation [18]. Although there are a variety of computer-based assessments for auditory selective/sustained attention available such as Test of Sustained Selective Attention (TOSSA) [19] it seems there is a limitation in computer-based assessments for visual sustained attention accordance the preschool children's conditions.

To obviate this shortage and for achieving this aim-designing the sustained attention test for children-several importance factor which are necessary to consider are as follow: 1) The stimulus should be pictorial for illiterate children. Among the various figures the use of geometrical shapes is preferable for preschool children in two reasons: they can understand and give answer to geometrical shapes immediately just like in written concepts [20] and the other is recognition of geometrical shapes is prerequisite for mathematics performance in 4-6 years old kids [21].

2) Designing the task in a game format in order to attracting more attention and engaged kids into meaningful activity [18]. Games can also contribute to the improvement of flexibility of cognition [22].

3) Attention to the task should be assessed in both visual fields because the right hemisphere communicated to both visual field but the left hemisphere predominantly communicated to right visual field [4]. Based on these points, this study aimed to develop and examine the psychometric characteristics (content, face and convergent validity and test-retest and internal consistency reliability) of the computer-based Sustained Visual Attention Test (SuVAT).

## Methods

This study was carried out in two phases:

### *Phase 1: Designing and constructing the computer-based test*

SuVAT was developed in two versions: original and parallel; which in both versions stimuli presented randomly. The parallel test was also designed in order to; 1) Reduce the learning effect whenever need, 2) Facilitate the determination of reliability of test-retest and to prevent the effects of learning from influencing the test result.

In order to examine the internal consistency of the test (using Cronbach's alpha), the original version has two stimuli presentation order format: random and non-random. However, the non-random order of original version of SuVAT used only for assessing test-retest reliability.

### *Selecting Stimuli*

As reading skills have not yet been developed in preschoolers, the stimuli in SuVAT were shapes [21]. According to evidences which recorded the association between mathematical skills and sustained attention [23] this research utilized geometrical shapes (appropriate for the age of preschool children) as stimuli in the test [24].

Two type stimuli were selected for SuVAT: Target stimulus which was square for original version and triangle for parallel version; and non-target stimuli which were star, circle, hexagonal, parallelogram. In total, the test had 15 target stimuli (20% of the total stimuli) and 60 non-target stimuli (80% of the total stimuli).

### *Task Design*

The test consist of 75 trials in 3 sets: In the first set which consists of 25 trials, one stimulus appeared at the center of the visual field. In the second 25 trial-set, two stimuli appeared at the left and right visual fields. For third 25 trial-set three stimuli appear at the center, left-hand and right-hand sides of the visual field. Each trial presented for 1000 milliseconds and between each trial; a fixation point+appear for 500 milliseconds. During each trial, the child had to press the space key of keyboard whenever the target stimuli appeared (Figure 1).

Beside, based on our previous record [25] and the conclusion of expert panel, the color of the task's background and stimuli are gray and black respectively.

### *Software*

The software was written in C SHARP programming language and can run in the Microsoft Office software with the ability to record the reaction time in milliseconds.

### *Phase 2: Examining psychometric properties*

#### *Participants*

Experts: Inclusion criteria for the experts were; having published at least one article related to the subject and having five years of academic experience.

Pre-school children: The inclusion criteria for all stages of this study were: normal visual acuity, normal visual field (using Confrontation Test), 48 - 72 months old, and normal IQ, ( $IQ \geq 90$  using Raven Intelligence Questionnaire). Participants who had a history of

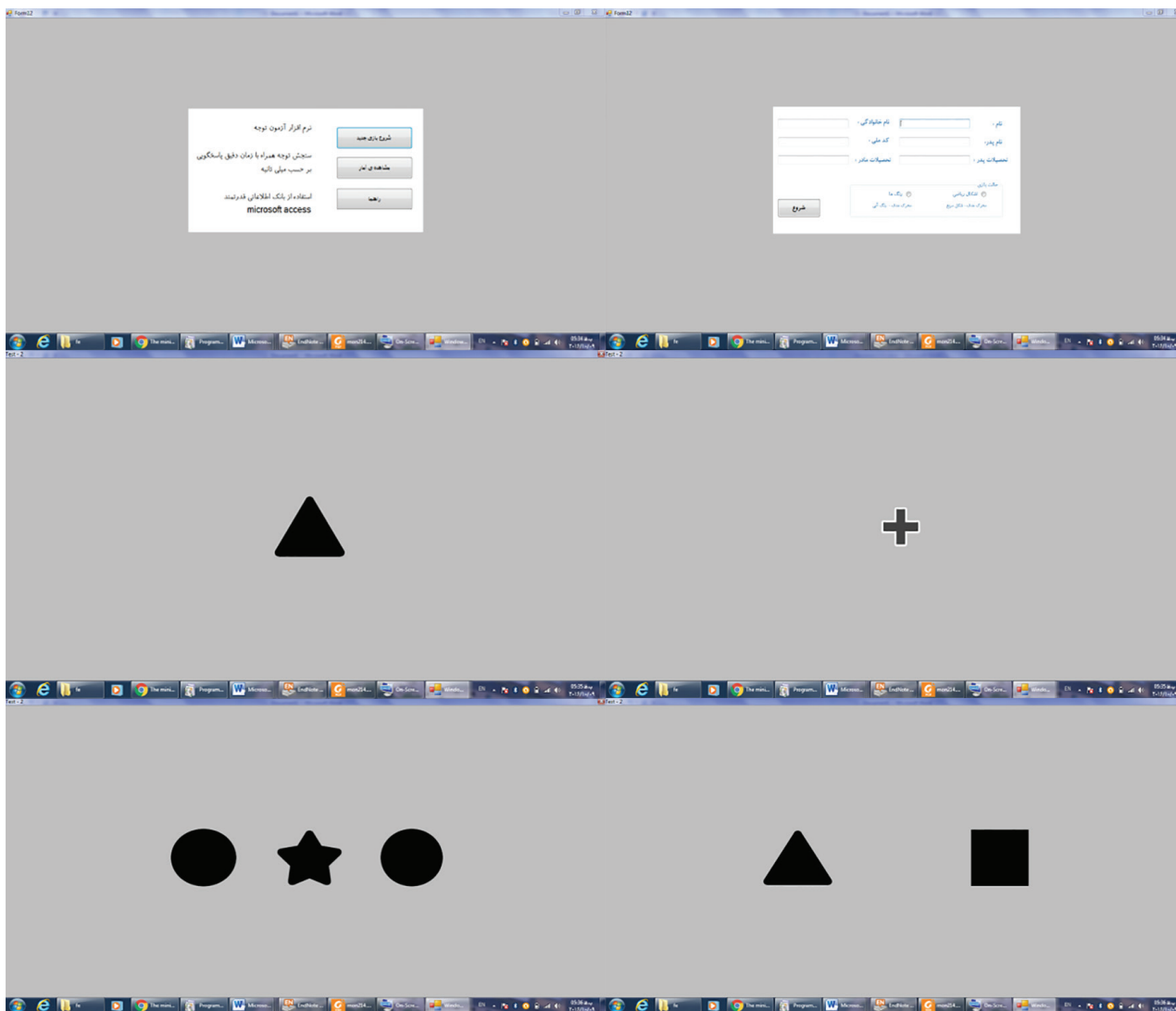


Figure 1: Task Design

neurological diseases, loss of consciousness due to head injury, history of epilepsy and other medical conditions were excluded from this study.

*Content Validity*

Ten experts (four occupational therapists, two neuroscientists, two speech therapists, and two psychoanalysts) participated in this phase of the study. The experts examined the necessity of existence of each item based on Content Validity Ratio (CVR) according to Lawshe’s method [26] and investigated relevance, simplicity, and clarity based on Content Validity Index (CVI) and on Waltz and Basel method [27].

*Face Validity*

Ten children were asked about the attractiveness, duration of each trial, the degree of difficulty of the SuVAT. They were given scores ranging from 0 to 10 based on Visual Analog Scale (VAS) (zero indicated tediousness with a tired and sad face and 10 the maximum degree of interest with a happy face) to trials and total test [15]. Finally, the child was asked if he/she wished to play the game again.

*Convergent Validity*

Fifty four pre-school children (31 girls with the mean age of 60.63naem eht htiw syob 32 dna shtnom 36.6± dna TAVuS yb dessessa erew (shtnom 33.7±4.06 fo ega [82] (narI ,cnI aniSnavaR) TPC fo noisrev naisreP

*Instrument*

Persian version of CPT (P-CPT) was used for this study [28]. This version has two stages. In the first stage as a training phase the participants were learning how to click the target stimuli (by pressing the “space” button when a candle appear), without recording the results. The evaluation version of P-CPT consists of 150 stimuli (familiar shapes-30 target, 120 non-target) each stimulus was presented on the computer monitor for 200 milliseconds, with 1000 milliseconds interval between each stimuli.

*Reliability*

To examine the test-retest reliabilitynon-random versions of original and parallel of SuVAT was used and for this stage 38 children (21 girls and 17 boys) who met the inclusion criteria were taken part. Moreover, for

assessing the internal consistency reliability thirty eligible pre-school children (17 girls and 13 boys) took part.

#### Procedure

All participants were seated comfortably on a chair in a quiet room at their kindergarten in the morning during 8-12 am. The distance from monitor was 50 cm. Before the experiment, they had a snack. They had 5-10 minutes resting time between the original and parallel version of SuVAT and Persian version of CPT tests. All the tests were installed on a laptop (Lenovo Idea Pad 300 - E – 15.6 inch full HD). Subjects were initially familiar about the overall procedure (by training in practice block) and clicked on the correct stimuli using the mouse. The ethical protocol of this study was based on the approval from the Ethic committee of Iran University of Medical sciences (IUMS), with 93/d/105/4940 code and signed by all participants and one of their parents. Written informed consent was received prior to enrollment.

#### Statistical Analyses

The Result of the Kolmogorov-Smirnov test determined the non-normal distribution of the CPT test data and normal distribution of original and parallel versions of SuVAT. For the evaluation face validity the mean of Visual Analog Scale (VAS) were considered. The Pearson correlation coefficients, intra-class Correlation Coefficient (ICC) and Cronbach's alpha coefficients were used to examine the convergent validity, test-retest reliability and internal consistency, respectively. The analysis was done in SPSS 18.0 (Sciences Statistical Package for the Social). A significance level of 0.05 was considered for all comparisons. The reliability correlation coefficients less than 0.4, between 0.4 and 0.7 and more than 0.7 were considered as weak, tolerable to fine and great reliability, respectively [29].

## Results

#### Content Validity

Content Validity means the items that make up an instrument adequately sample the universe of possible items that compose the construct being measured, typically assessed by measuring agreement between subject matter experts using Content Validity Ratio (CVR) and Content Validity Index (CVI) [26].

For CVR 18 items of the sustained attention test were examined by ten experts. The CVR for all items excluding two (background's color CVR=0.8 and stimuli's color CVR=0.8) were equal to 1, and the Content Validity Index (CVI) was 0.98.

#### Face Validity

Face validity is an assumption that an instrument is valid based on its appearance (i.e. it is a reasonable measure of the variable being assessed).

Based on the information obtained from ten preschool children, the test was remarkable ( $n=10$ , 100%), trial time was sufficient ( $n=10$ , 100%), and the degree of difficulty was acceptable ( $n=9$ , 90%). The mean of the attractiveness

of the test based on VAS was 9.8.

#### Internal Consistency

Internal consistency is the extent to which items in the same instrument all measure the same trait. The Internal consistency was calculated using Cronbach's alpha. It indicates an excellent value for internal consistency (Cronbach's alpha=0.87).

#### Convergent Validity

Convergent validity refers to the degree to which two measures demonstrate similar results. The degree to which these two assessments converge provides evidence of the new measure's validity.

Pearson correlation coefficient "r" was used for convergent validity assessment. Selected variables were correct, commission and omitted answers, plus the reaction time in SuVAT test and CPT test. The value of r for correct answers was 0.891, for commission answers, 0.806, for omitted answers 0.857, and for reaction time 0.835. Excellent correlation was seen)

Test-retest Reliability and Standard Error of Measurement (SEM)

Intra Class Correlations (ICC) was used for test-retest reliability assessment. ICC of SuVAT (correct answer) is 0.924, of Commissions is 0.871, of Omissions is 0.897 and of reaction time is 0.842.

#### Minimal Detectable Change (MDC)

A statistical estimate of the smallest amount of change that can be detected by a measure that corresponds to a noticeable change in ability.

The MDC is calculated in terms of confidence of predication. For example, MDC95 is based on a 95% confidence interval, while a MDC90 is based on a 90% confidence interval. For almost all Rehabilitation Measures, the MDC95 is used and the following equation was utilized to calculate it:  $MDC=1.96 SEM \sqrt{2}$

MDC for correct answer is 1.61 rounded to 2; for commissions is 1.1 rounded to 2; for omissions is 1.3 rounded up to 2 and for reaction time is 39.7 rounded to 40. All the above results are summarized in the Table 1.

## Discussion

Attention is not only a main prerequisite for memory and learning skills, but also a crucial factor for school achievement and job successes in adulthood. Obviously, the early evaluation and intervention of this skill in pre-school children is essential as a first step of prevention of mental health illness.

Adults with ADHD may have trouble managing time, being organized, setting goals, and holding down a job and these problem endangered their mental health.

There are various models of attention for adults; however there is a lack of conceptual or practical attention model in children [30]. This is due to the overlap of attention models and other skills, such as executive function, language skills, and visual perception [31]. Hence, attention test in preschool children might be affected by

**Table 1:** The reliability and validity of SuVAT

Variable	Conver.Validity * (using CPT test & n=54)	Mean Test SuVAT	SD Test SuVAT	ICC (n=38)	SEM*	MDC**	MDC#
Correct	0.891	72.526	2.102	0.924	0.579	1.61	2
Commissions	0.806	1.053	1.1137	0.871	0.400	1.11	2
Omissions	0.857	1.421	1.4451	0.897	0.464	1.29	2
Reaction Time	0.835	315.395	36.0439	0.842	14.327	39.71	40

\*Standard Error of Measurement; \*\* Minimal Detectable Change

development of other skills [15].

Therefore, the lack of knowledge in this field is a limitation for designing the appropriate task for intervention and evaluation of cognitive skills in preschool children. The aim of this study was to design and examine the psychometric characteristics of a computer-based test (SuVAT) in order to evaluate the sustained attention of pre-school children aged 4-6.

#### Design SuVAT

In order to design the cognitive task/test, the psychophysics' factors such as type and location of stimuli, number of target and non-target stimulus, position of target stimulus with respect to other stimuli, background color, duration of presenting the stimuli [32,33] and static or dynamic stimuli [34] should be considered. In this study, these factors were considered based on review the evidences [15,35] and expert panel.

The geometrical shapes were selected as the stimuli in SuVAT in two reasons: The first, in the large body of evidence on children with poor mathematics performance reveals that the main problem of children were deficits in working memory, sustaining and controlling attention, ignoring irrelevant information, and poor problem-solving ability [36] it means the close relationship between sustain attention and the mathematics skills. The second reason, perception and recognition of geometry skills and spatial reasoning during early childhood are the most important prerequisite for learning of mathematics and other subjects in the school. These concept formations begin in the preschool years and stabilize as early as age 6 and an ideal period to learn about shapes is between 3 and 6 years of age [37]. In conclude, assessing the degree of maintaining attention of preschool children by their basic mathematical recognition abilities and use of interfering stimuli to make the test more difficult to achieve more accurate responses [6] is the unique feature of SuVAT.

#### SuVAT Validity

Content validity of SuVAT was approved by expert panel. They considered the stimuli, psychophysics characteristics, and the uniformity of subgroups of SuVAT are suitable for the evaluation of sustained attention.

The results obtained from convergent validity indicate a strong and meaningful association between SuVAT and CPT which suggests that SuVAT might be an appropriate tool for the evaluation of sustained attention. However, the results of face validity revealed that the participants preferred the SuVAT because they found it as an interested game which they wanted to repeat it. They also showed that CPT was tedious for them since the duration time

for implementation is too long.

#### SuVAT Reliability

The test-retest reliability of the SuVAT was developed in original and parallel versions in order to limit the learning effect. The results indicated not only two versions of SuVAT are interchangeable in pre-school children, but also they have good repeatability.

The two versions of the SuVAT showed the high internal consistency. In other words, the three sets of SuVAT have strong relationship and these various subgroups of the test are strongly interdependent and the test has a high degree of sensitivity.

To examine the psychometric characteristics of SuVAT in different age groups and disorders such as hyperactivity and attention deficit disorder, learning disorder, and pervasive developmental disorder are suggested for future studies.

The main limitation of this study is lack of the computerized sustained attention in pre-school children for assessing convergent validity.

#### Conclusion

The computer-based Sustained Attention Test (SuVAT) is an assessment with simple implementation for evaluating sustained attention. It does not require reading skills, and given the good validity and reliability of SuVAT, it can be used along with other kinds of cognitive tests. Moreover, regarding the test as a game, children were fully cooperative during the test session. Certainly, for applicability, every cognitive test needs to be tried for other age groups, and subgroups of cognitive disorders.

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**Conflict of interest:** None declared.

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