



# Adult Performance on the Sustained Auditory Attention Skill Test

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## Abstract

**Introduction** The Sustained Auditory Attention Ability Test (SAAAT) is an instrument used to assess sustained auditory attention in children. Difficulties related to this ability are not unique to children alone, as adults have been observed to present with the same deficits. Therefore, there is a need to adapt instruments like the SAAAT and provide reference values for adults.

**Objective** To assess adult performance on the SAAAT.

**Methods** Approved by the Human Research Ethics Committee under n° 034/2011. The sample consisted of 30 participants aged between 18 and 30 years old (average age = 24.2 years old), female and male. The inclusion criteria were: peripheral hearing within normal limits, type A tympanometric curve, and no attention-related complaints. The participants were submitted to Tonal Audiometry, Logaudiometry, Immitanciometry and to the SAAAT.

**Results** The following mean values and standard deviations (SD) were observed: inattention = 1.7 (SD = 2.2) and impulsivity = 0.8 (SD = 0.9) error types. For the SAAAT, the mean value for the total error score was 2.4 (SD = 2.6), and for the decrease in vigilance, it was 0.3 (SD = 0.5). When comparing the performance of adults and children, a statistically significant difference was observed for inattention ( $p = 0.000$ ) and impulsivity ( $p = 0.001$ ) error types, as well as in the total error score ( $p = 0.000$ ) and in decreased vigilance ( $p = 0.0003$ ).

**Conclusion** The performance of adults in the SAAAT differed from the children's parameters, since adults showed lower scores in all variables of the instrument.

## Keywords

- ▶ attention
- ▶ hearing
- ▶ adult

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## Introduction

Attention is a complex cognitive function, necessary for learning, following behavioral social norms, and performing responsibilities and duties effectively.<sup>1</sup> Several studies are available on attention in children. However, learning does not occur only during childhood. New skills are acquired throughout a lifespan, and for learning to take place, attention and memory are involved, especially incidental memory.<sup>2</sup>

Attention can be divided into focused attention, selective attention, alternate attention, divided attention and sustained attention.<sup>3,4</sup> The latter is required in various professional activities in adulthood, such as driving or medical-related activities.<sup>1</sup>

The Sustained Auditory Attention Ability Test (SAAAT) is a clinically used instrument to measure sustained auditory attention, which has been translated and adapted for the Brazilian population up to the age of 11 years old.<sup>5</sup> The SAAAT adaptation study consisted of 6 groups of children aged between 6 and 11 years old, divided by age group (G1: 6 years old; G2: 7 years old; G3: 8 years old; G4: 9 years old; G5: 10 years old, and G6: 11 years old). The study concluded that the SAAAT scores were correlated with the age of the child because the younger the age, the higher the number of errors (inattention and impulsivity), and consequently the higher the total error score. A greater decrease in vigilance was observed in children aged between 6 and 8 years old than in those between 9 and 11 years old.

After its linguistic and cultural adaptation to Brazilian Portuguese, up until the year of 2013, this test was applied exclusively to children.<sup>5-9</sup> However, it was observed that in clinical practice, adults showed lower SAAAT test scores compared with results found in children 11 years old, as this age was the highest available age range for the test.

The lack of studies investigating sustained auditory attention ability in adults and the observed score difference in the SAAAT when applied to this age group demonstrates a possible need for a valid adult test.

The purpose of the present study is to assess the performance of adults in the SAAAT.

## Methods

The present research project was submitted to the Human Research Ethics Committee of the institution where it was developed, under protocol number 034/2011.

Thirty adults were part of the present study, aged between 18 and 30 years old (mean age = 24.2 years old; standard deviation = 3.1), female ( $n = 15$ ) and male ( $n = 15$ ). The predominant levels of education were completed college (53.3%;  $n = 16$ ), followed by uncompleted college (40%;  $n = 12$ ) and completed high school (6.7%;  $n = 2$ ). The inclusion criteria for participating in the study were: peripheral hearing within normal range, bilaterally verified by pure tone audiometry, with thresholds considered normal up to 25 decibel level of hearing (dBHL),<sup>10</sup> as well as normal middle ear function assessed by tympanometry, showing a total of 100% type A

tympanometric curves.<sup>11</sup> Another inclusion criterion was no complaints related to attention.

The sample population was recruited by invitation to undergraduate students of the institution where the study was conducted and by volunteers living in a country-side city in the state of São Paulo, Brazil. The sample had to have no previous contact with the SAAAT. Participants who did not agree with the procedures or did not sign the Informed Consent Form were excluded from the study.

A questionnaire was included to verify aspects related to attention ability, previously to the application of the proposed procedures. The questionnaire was the one<sup>7,12</sup> used to verify the auditory attention ability in children, but adapted for application in adults.

After applying the attention questionnaire, the participants, who had no attention-related complaints and met the inclusion criteria, were submitted to Tonal Audiometry, Logoaudiometry (Midimate 622 - Madsen Eletronics audiometer, GN Otometrics A/S, Copenhagen, Denmark), Immittance (SD 30; Siemens, Munich, Germany) and the SAAAT for the purpose of assessing sustained hearing attention (Midimate 622 - Madsen Eletronics audiometer, GN Otometrics A/S, Copenhagen, Denmark).

Air thresholds were investigated in an acoustically treated cabin, to verify audiometric thresholds, at frequencies from 250 Hz to 8,000 Hz for the right and left ear. The degree of hearing loss was classified using the audiometric thresholds of the frequencies of 500, 1,000, 2,000 and 4,000 Hz, classified as mild (mean 26 to 40 dBHL), moderate (mean 41 to 60 dBHL), severe (mean 61 to 80 dBHL) and deep (mean > 81 dBHL) according to the World Health Organization (WHO).<sup>10</sup> When air thresholds > 25 dBHL were detected, bone audiometry was performed to characterize the type of hearing loss (sensorineural, conductive or mixed). Logoaudiometry was performed to confirm tonal thresholds and to verify word detection and recognition capacity. Afterward, participants underwent immittance monitoring to verify the tympanic-ossicular conditions and the integrity of the auditory pathway. Participants diagnosed with hearing loss were advised of the change found and were referred to a health unit of their choice for appropriate management.

After this stage, all of the participants who met the inclusion criteria completed the SAAAT.

The SAAAT is based on the Auditory Continuous Performance Test (ACPT),<sup>13</sup> which is clinically employed to measure sustained auditory attention.<sup>5</sup>

The SAAAT<sup>5</sup> is an instrument used to verify the ability of the subject to hear words over a prolonged period of time (11 minutes). Subjects raise their hand to a specific stimulus (target word "no"). The test contains 21 monosyllabic words arranged in a 100-word list format that is repeated six times without interruption during the test at the rate of one word per second. During the list of 100 words, there is an incidence of the word "no" 20 times, requiring a task of hearing surveillance from the assessed subject. The test was provided in a Compact Disc (CD) format with the aid of a CDP 4147 CD player (Toshiba, Tokyo, Japan), coupled with a Midimate

**Table 1** Mean values, standard deviation and prevalence of inattention errors in males and females

Gender	N	Mean	SD	1st quartile	Median	3rd quartile	p-value
Female	15	1.2	1.8	0.0	0.0	2.0	0.285
Male	15	2.1	2.4	0.0	1.0	5.0	
Total	30	1.7	2.2	0.0	0.5	4.0	—

Abbreviations: N, Number; SD, standard deviation.  
 p: the difference between SAAAT variable means in males and females.  
 Statistical test: Mann-Whitney test.

622 two-channel audiometer (Midimate 622 - Madsen Electronics, GN Otometrics A/S, Copenhagen, Denmark) and performed diotically (same information in both ears), with an intensity of 50 dBHL above the tritonal average of the frequencies from 500Hz to 2,000Hz.

Participants were verbally instructed by the evaluator that they would hear a list of words and that they should raise their hand whenever they hear the word “NO.” The test began only after learning and understanding the test (after the first 50 words). Responses were recorded following a specific protocol with an “x” in front of each test word for which the participant raised his hand. All evaluations were performed by the same researcher.

Results of the SAAAT include the total error score and the decrease in vigilance. The total error score is obtained by summing the number of inattention (when the participant did not raise his hand when hearing the word “NO” before the next word was presented) with the number of impulsiveness (when the participant raised the hand to another word instead of the word “NO”). The decrease in vigilance, that is, the decline in attention that occurred overtime during the surveillance task, was obtained by calculating the difference between the number of correct answers in the 1<sup>st</sup> and 6<sup>th</sup> presentation of the SAAAT word list.

The tests used for statistical analyses were: The Mann-Whitney Test to verify the association between gender in all SAAAT variables (inattention, impulsivity, total error score, and decreased vigilance). The Spearman correlation test was used to verify the correlation between age and education variables and the variables in the SAAAT. The Spearman correlation coefficient was used to verify the correlation between all SAAAT variables and age. The comparison between the groups of 11-year-old children<sup>5</sup> and adults for the variables of inattention, impulsivity, total error score and decreased vigilance was performed using the

Mann-Whitney test. The statistical significance level adopted was  $p \leq 0.05$ .

**Results**

► **Table 1** shows the distribution of the mean scores obtained by the participants and the influence of the gender variable, considering the inattention errors, based on the SAAAT results.

► **Table 2** shows the distribution of the mean scores obtained by the participants and the influence of the gender variable, considering the impulsivity errors, based on the SAAAT results.

► **Table 3** shows the distribution of the mean scores obtained by the participants and the influence of the gender variable, considering the total error score.

► **Table 4** shows the distribution of the mean scores obtained by the participants and the influence of the gender variable, considering the decrease in vigilance.

A correlation was obtained with the variables total error score ( $R = 0.114$ ;  $p = 0.547$ ), decreased vigilance ( $R = -0.220$ ;  $p = 0.241$ ), inattention ( $R = 0.049$ ;  $p = 0.793$ ) and impulsivity ( $R = 0.077$ ;  $p = 0.683$ ), to verify the influence of age on the performance of SAAAT in the sampled group. No correlation was observed between age and all SAAAT variables (Statistical Test: Spearman Correlation).

>A correlation was obtained between educational level and total score of errors ( $R = 0.098$ ;  $p = 0.603$ ), decreased vigilance ( $R = -0.352$ ;  $p = 0.056$ ), inattention ( $R = -0.033$ ;  $p = 0.858$ ) and impulsivity ( $R = 0.121$ ;  $p = 0.521$ ). No correlation was observed between education level and all SAAAT variables (Statistical Test: Spearman Correlation).

A comparison was made between the group of children aged 11 years old<sup>5</sup> and the group of adults in the present study, to verify whether there is a statistically significant difference between the two groups, as shown in ► **Table 5**.

**Table 2** Mean values, standard deviation and prevalence of impulsivity errors in males and females

Gender	N	Mean	SD	1st quartile	Median	3rd quartile	p-value
Female	15	0.6	0.9	0.0	0.0	1.0	0.187
Male	15	1.0	0.8	0.0	1.0	2.0	
Total	30	0.8	0.9	0.0	0.5	2.0	—

Abbreviations: N, Number; SD, standard deviation.  
 p: the difference between SAAAT variable means in males and females.  
 Statistical test: Mann-Whitney test.

**Table 3** Mean values, standard deviation and prevalence of total error score in males and females

Gender	N	Mean	SD	1st quartile	Median	3rd quartile	<i>p</i> -value
Female	15	1.8	2.1	0.0	1.0	2.0	0.232
Male	15	3.1	2.8	1.0	2.0	6.0	
Total	30	2.4	2.6	0.0	1.0	5.0	–

Abbreviations: N, Number; SD, standard deviation.

*p*: the difference between SAAAT variable means in males and females.

Statistical test: Mann-Whitney test.

**Table 4** Mean values, standard deviation and prevalence of decrease in vigilance in males and females

Gender	N	Mean	SD	1st quartile	Median	3rd quartile	<i>p</i> -value
Female	15	0.3	0.4	0.0	0.0	1.0	0.934
Male	15	0.4	0.6	0.0	0.0	1.0	
Total	30	0.3	0.5	0.0	0.0	1.0	–

Abbreviations: N, Number; SD, standard deviation.

*p*: the difference between SAAAT variable means in males and females.

Statistical test: Mann-Whitney test.

**Table 5** Mean values and standard deviation for inattention, impulsivity, total error score and decrease in vigilance among the 11-year-old and adult groups in the SAAAT

Group	N	Inattention		Impulsivity		Total Error Score		Decrease in Vigilance	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Children	40	8.6	8.4	2.4	2.2	11.0	9.0	1.4	1.6
Adults	30	1.7	2.2	0.8	0.9	2.4	2.6	0.3	0.5
<i>p</i> -value		0.000*		0.001*		0.000*		0.003*	

Abbreviations: N, Number; SD, standard deviation.

*p*: the difference between SAAAT variable means in the group of children and adults

\*statistically significant difference.

Statistical test: Mann-Whitney test.

## Discussion

The SAAAT is an instrument used to verify the sustained auditory attention ability in children. However, difficulties related to this ability are not exclusive to children, as they can also be observed in adults. The adaptation of this instrument to the adult population may help provide reference values for adults, investigate this ability in adults, and provide a complementary test to verify the attention ability in the assessment of central auditory processing.

No statistically significant difference was observed between variables (inattention, impulsiveness, total errors and decreased vigilance) and the gender of the participants evaluated (► **Tables 1 to 4**), which was in agreement with other studies that used the SAAAT in children.<sup>5–9</sup> According to the results found with adults in the present study, it was observed that gender was not an aspect that influenced the ability of sustained auditory attention. These results were consistent with similar studies with children.

The mean value for inattention errors (► **Table 1**) was 1.7 (SD = 2.2) and for impulsivity (► **Table 2**) it was 0.8

(SD = 0.9). These results were lower than those found in studies with Brazilian children.<sup>5–9,14,15</sup> As such, there was a decrease in the types of errors found in adults, which may suggest that sustained auditory attention may continue to improve until adulthood.

The total error score (► **Table 3**) showed a mean of 2.4.<sup>2,6</sup> These results were lower when compared with studies with Brazilian children.<sup>5–9,14,15</sup> A study that applied the SAAAT in adults<sup>16</sup> found mean values of total error scores ranging from 1.00 (SD = 1.30) to 3.26 (SD = 5.86). These values were closer to those found in the present study compared with studies with children.<sup>5–9,14,15</sup> The total error score considers the sum of inattention and impulsivity error types. Thus, a decrease in these types of errors in adults shows that after 11 years old, sustained attention continues to develop until adulthood.

The mean value for the decrease in vigilance (► **Table 4**) was 0.3 (SD = 0.5). This result was also lower compared with studies with Brazilian children.<sup>5–9,14,15</sup> Lima et al<sup>16</sup> found values between 0.86 (SD = 1.18) and 0.46 (SD = 0.74), agreeing with the lowest values in the decrease in vigilance observed in the present study. This result demonstrates

that adults have greater control over attention span and achieve a better sustained hearing attention maintenance compared with children.

No correlation was observed between age and the SAAAT variables, hence no difference may be inferred whether participants were closer to 18 or 30 years old. These data differed from those found in children, as younger children had worse performance on the SAAAT compared with older children.<sup>5</sup> Thus, it can be observed that sustained auditory attention ability continues to develop and improve during childhood, while in adulthood it is already consolidated. No change in the performance parameters was observed among adults aged 18 to 30 years old. The total error score and the decrease in vigilance score in the SAAAT can be used as standard norm values for inattention and impulsivity error types.

There was no correlation between education and all the test variables, showing that education level did not influence the SAAAT performance for this group. Picolini et al<sup>8</sup> conducted a study that found that 7-year-old children who attended afternoon public schools showed worse SAAAT scores than children who attended private morning schools, observing a possible influence of the type and time period of school on the SAAAT performance. Some studies<sup>1,17</sup> found a correlation between school years and sustained attention. The Integrated Visual and Auditory Continuous Performance Test software was applied to 400 women, aged 20 to 50 years old (mean age = 34.4 years old), and the results showed that the higher the education level, the better performance in the sustained attention tests. These data differed from those found in the present study. It is suggested that the small number of participants, as well as the absence of lower educational levels (elementary school and illiterate people), may have influenced the results. It is recommended to include an investigation of educational level and sustained auditory attention in adults in future studies, by including different levels of education and a greater number of participants.

When comparing all SAAAT variables in children and adults (► **Table 5**), it was found that the mean values obtained in 11-year-old children were higher than those found in adults. These findings reinforce the importance of testing this population to verify the performance parameters of adults. A study<sup>16</sup> using the SAAAT, conducted on adults with and without tinnitus, found better performance in both the study group (tinnitus) and the control group (without tinnitus), as shown by the lower total error score and decreased vigilance in adults compared with children.<sup>5-9,14,15</sup>

Roebuck et al<sup>18</sup> conducted a study to verify the influence of stimulus type (verbal and nonverbal) on continuous performance tasks in 31 children (aged 8 to 12 years old) and in 32 adults (aged 18 to 50 years old). The study showed no language, cognitive or auditory changes. The authors found that adults showed lower values of omission errors and percentage of incorrect responses to different stimuli provided. These data agree with the results found in the present study, where adults showed lower amounts of inattention and impulsivity errors compared with 11-year-olds, and consequently a higher performance.

One limitation of the present study was the difficulty in finding current studies in the literature on sustained auditory attention tests applied in adults in the Brazilian population.

## Conclusion

The performance of adults in the SAAAT differed from the parameters used in children, as adults presented with lower scores in the types of inattention and impulsivity error, as well as in the total score of errors and decreased vigilance.

### Note

José M. R. performed data collection, tabulation, literature review and manuscript writing; Mondelli M. F. C. G., Correia J. B., Bohn V and Lauris J. R. P. performed the literature review, manuscript writing and final revision; Feniman M. R. was responsible for the project and study design, in addition to general supervision of the performance steps and manuscript elaboration.

### Conflict of Interests

The authors have no conflict of interests to declare.

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