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Children Sustained Attention Task (CSAT): Normative, reliability, and validity data

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ABSTRACT. Sustained attention has been shown to be related to several clinical disorders, such as attention deficit hyperactivity disorder (ADHD) or learning disabilities. Sustained attention can be studied from two related but independent paradigms represented by the continuous performance test (CPT) and the vigilance tasks. The Children Sustained Attention Task (CSAT) is a computerized vigilance task. The aim of this instrumental study is to analyse some of its psychometrics properties related to standarization, realiability, and construct validity. The CSAT was given to a random sample of 584 6-11-year-old children, which were categorised into four age groups. The dependent variables were academic performance and the inattention and hyperactivity measures from Edelbrock's Child Attention Problems Scale. The results showed improved performance with older age for all CSAT variables, while there were no significant gender-related differences. Test-retest reliability ranged from .59 and .88. As predicted, CSAT measures (specially hits, d' and A') were more related to inattention and academic performance than hyperactivity. In short, CSAT has showed good psychometric indices and it is proposed to use in further applied or clinical studies.

KEYWORDS. Sustained attention. Continuous performance tests. Children. Instrumental study.

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RESUMEN. La atención sostenida ha demostrado estar relacionada con diferentes problemas clínicos, tales como el trastorno por déficit de atención e hiperactividad (TDAH) y los trastornos de aprendizaje. La atención sostenida puede estudiarse desde dos paradigmas relacionados pero independientes representados por los tests de ejecución continua (*CPT*) y las tareas de vigilancia. La Tarea de Atención Sostenida en la Infancia (*CSAT*) es una tarea de vigilancia. El propósito de este estudio instrumental es analizar algunas de sus propiedades psicométricas, relacionadas con la estandarización, fiabilidad y validez de constructo. La *CSAT* se administró a una muestra de 584 niños de entre 6 y 11 años, que fueron clasificados en cuatro grupos de edad. Las variables dependientes fueron el rendimiento académico y las medidas de inatención y sobreactividad de la *Edelbrock's Child Attention Problems Scale*. Los resultados muestran que con la edad mejoran todas las puntuaciones de la *CSAT*, sin que se observen diferencias por género. La fiabilidad test-retest fluctuó entre 0,59 y 0,88. Las medidas de la *CSAT* (especialmente los aciertos, d' y A'), tal y como se hipotetizó, mostraron más implicaciones con la inatención y el rendimiento que con la sobreactividad. En resumen, la *CSAT* ha demostrado buenos índices psicométricos y se propone su utilización en futuros estudios clínicos o aplicados.

KEYWORDS. Atención sostenida. Tests de ejecución continua. Niños. Estudio instrumental.

RESUMO. Tem sido demonstrado que a atenção sustentada está relacionada com diferentes problemas clínicos, tais como a perturbação por défice de atenção e hiperactividade (TDAH) e as perturbações de aprendizagem. A atenção continuada pode estudar-se a partir dos paradigmas relacionados mas independentes representados pelos testes de execução contínua (*CPT*) e as tarefas de vigilância. A tarefa de Atenção Continuada na Infância (*CSAT*) é uma tarefa de vigilância. O propósito deste estudo instrumental é analisar algumas das suas propriedades psicométricas, relacionadas com a estandardização, fidelidade e validade de construto. A *CSAT* foi administrada a uma amostra de 584 crianças com idades entre 6 e 11 anos, que foram classificados em 4 grupos de idade. As variáveis dependentes foram o rendimento académico e as medidas de desatenção e hiperactividade de *Edelbrock's Child Attention Problems Scale*. Os resultados mostram que com a idade melhoram todas as pontuações da *CSAT*, sem que se observem diferenças por género. A fidelidade teste-reteste flutuou entre 0,59 y 0,88. As medidas da *CSAT* (especialmente os acertos, d' e A'), tal como se hipotetizou, mostraram mais implicações com a desatenção e o rendimento que com a hiperactividade. Em resumo, a *CSAT* demonstrou bons índices psicométricos e propõe-se a sua utilização em futuros estudos clínicos ou aplicados.

PALAVRAS CHAVE. Atenção continuada. Testes de execução contínua. Crianças. Estudo instrumental.

Introduction

The Children Sustained Attention Task (CSAT) (Servera and Llabrés, 2004) is a computerised task based on the Continuous Performance Tests (CPTs) paradigm and designed to use with children from 6 until 11 years old. Rosvold, Mirsky, Sarason,

Bransome, and Beck (1956) define the structure of a what is now a CPT, as follows: for a shorter or longer period of time the subject is attentive to the presentation of distracting stimuli and must respond solely to a previously defined target stimulus. In child psychopathology the use of CPTs has been essentially centred on Attention-Deficit/Hyperactivity Disorder (ADHD) (O'Dougherty, Neuchterlein, and Drew, 1984). While some reviews report relatively encouraging data for their use (Epstein *et al.*, 2003; Losier, McGrath, and Klein, 1996; Rapport, Chung, Shore, Denney, and Isaacs, 2000), other studies are more critical (Corkum and Siegel, 1993; McGee, Clark, and Symons, 2000; Schachar, Logan, Waschsmuth, and Chajczyk, 1988). Though these conflicting views may be due to methodological problems, they may also owe themselves to the characteristics of the different types of CPTs used. Generally speaking, we might say that there are two types of CPTs, which coincide with the two basic cortical mechanisms of sustained attention, according to the Sergeant's energetic model (see Berlin, Bohlin, Nyberg, and Jacobs, 2003; Sergeant, 2000; Van der Meere, 1996): CPT as a vigilance task (centred on the activation mechanism) and CPT as an inhibition task (centred on the arousal mechanism). In vigilance CPTs, known as X- or AX- test types, the subject is attentive to distracting stimuli for a certain length of time and is asked to only respond to the target. In inhibition CPTs, or non –X test types, the subject is asked to respond continuously to any stimulus except for the target. It is this second type of test that is predominant in the children's clinical environment, which is particularly represented by Conners' CPT-II (Conners, 2000). The advantage of using inhibition CPTs in the assessment of ADHD has been justified by the following reasons (Conners, Epstein, Angold, and Klaric, 2003; Epstein *et al.*, 2003): a) they measure what is considered to be the central dimension in the explanation of the disorder (behavioural inhibition) (Barkley, 1997); b) they increase the probability of error rates, which means a greater variability in scoring; and c) they include measures of variability of reaction time and measures based on the signal detection theory (SDT). While the above-mentioned papers on the energetic model coincide in the importance of the measures of variability and SDT statistics, the comparative results in the assessment of children with ADHD seems to be inclined to use of vigilance CPTs.

The CSAT is a task based on the vigilance model, and may thus be considered a complementary measure of sustained attention to Conners' CPT-II with limitations and advantages. Its primary limitations reside in the fact that it does not enable measures of variability to be obtained, given its short length (some seven and a half minutes), and it is only applicable to children between the ages of 6 and 11. Its advantages, according to Servera and Llabrés (2004) technical guide, include the fact that it offers specific normative data for these school ages, while presenting good reliability and good construct validity (particularly through its correlation with the ADHD scales) and improving the use of the SDT-based measures. In this sense, we must point out that while most CPTs use the traditional statistic: d' (as a measure of attentional capacity) and Beta (as a measure of response style), the CSAT incorporates "nonparametric" statistics such as A' (sensibility o capacity) or C (response style), which do not require the assumption of normality and equal variances in the distributions of raw scores (Macmillan and Creelman, 1990).

Regarding to classification system for research methods of Montero and León (2005), we carry out an instrumental study of CSAT. The aim of this study is three-fold. First, we intend to analyse construct validity aspects of the CSAT through its capacity to make a distinction among the subjects of the four age groups for which it has been scaled, by means of both their direct scores and their SDT statistics. Our second purpose is to analyse aspects relating to the reliability of these measures. The third goal of this study is to analyse aspects of construct validity through their relation with measures of academic performance and teacher scales of inattention and hyperactivity. In this last case, our hypothesis is that the CSAT (as an attentional-cognitive measure) will be more capable of predicting the measures of inattention and academic performance than those of hyperactivity. We present the results according to Ramos-Alvarez and Catena's (2004) criteria for experimental methodology in Psychology.

Method

Subjects

Eleven school centres took part in this study. At each centre, between 20 and 25 children from each of the first four grades of elementary school education were evaluated, reaching a total of 996 subjects. These subjects were randomly selected from among all the children who met the following criteria for inclusion: a) they were not to be in any special education programme and did not present with any sort of psychopathological diagnosis, and b) they did not present with any serious conduct disorder. All the subjects were evaluated using the CSAT and the teachers' scales (see the section on instruments). Next, the extreme subjects and outliers for each age group were eliminated according to the variables of age mean, and CSAT hits and commission errors (i.e., the assumption of normality of these distributions were required). This process resulted in the loss of many subjects, particularly due to the variability in the scoring of commission errors. The outcome was a group of 584 subjects, which were distributed as described in Table 1.

TABLE 1. Number of children and age mean by age group and gender.

Age group	*Boys*	*Girls*	*Total*	*Age mean*	*SD*	*Minimum*	*Maximum*
1st	116	77	193	7.10	.30	6.10	7.48
2nd	84	62	146	8.00	.28	7.50	8.49
3rd	59	43	102	9.04	.30	8.51	9.48
4th	76	67	143	10.02	.31	9.51	11.23
Total	335	249	584	8.38	1.18	6.10	11.23

The interaction between age and gender was analysed, and the results showed only statistically significant differences in the age variable ($F_{(3, 583)} = 4833.23$, $p < .01$). The Scheffé *post-hoc* contrasts indicated clear differences among the four groups. A randomly selected sub-sample of 36 subjects was then used per age group ($n = 144$) for the test-retest reliability analyses. Some subjects were eliminated before correlation analyses (their teachers did not submit the scales), specifically 13 subjects from the first age group, 1 from the second, 9 from the third group, and 45 from the fourth.

Instruments

- The Children Sustained Attention Task (CSAT); (Servera and Llabrés, 2004). The task consisted of 600 stimuli (numbers from 0 to 9), approximately 3.5 cm (1.38 in.) in size, which appeared on the computer one at a time screen for approximately 250 ms., and their inter-stimulus interval was 500 ms. The target was double: 6-3 (30% of event rate). The task take approximately 7 min. and 30 sec. The dependent measures used in this study were hits (correct responses), reaction time, commission errors, and two SDT statistics: d' and A'. CSAT provide automatically these indices for each subject in accordance with their age from normative data. In both cases, the higher score indicates greater attentional capacity.
- Teachers' scales: a) the inattention and hyperactivity (motor behavior) subscales from Edelbrock's Child Attention Problems (CAP) scale -for a detailed description see Barkley (1990, pp. 302-305)-. In both cases, the higher score indicates greater problems; b) an academic performance scale ranging from 0 (poor) to 5 (very good).

Procedure

The CSAT was individually given in the mornings in the schools, by previously trained evaluators. Each subject completed a practice session until the examiner was confident that the child understood the task completely. The evaluators themselves also collected the teachers' scales. To analyse the differences among the subjects, two-factor (age *x* gender) ANOVA was performed for both the raw scores or direct measures (hits, commissions, and reaction time) and the SDT measures (d' and A'). Given that the gender factor was not significant, the Scheffé *post-hoc* contrasts (alpha = .05) were only applied to the age groups. As no homogeneity was detected, the data were analysed again using nonparametric tests: Kruskal-Wallis and Mann-Whitney. Reliability was analysed via test-retest procedure with a 7-9-day interval. The correlation analysis between the CSAT and the teachers' scales was based not only on significant coefficients but also greater than .20. Given the clear differences between the two younger age groups and the two older age groups, a separate regression analysis was then carried out. A multiple regression analysis was first carried out, including direct measures (hits, commission errors, and reaction time), followed by a simple regression analysis for d' and A' (it is not appropriate to include these variables in the multiple analyses, due to the obvious effect of colinearity that they produce). A coefficient of determination was provided for each regression analysis (R^2 adjusted), and the standardised partial regression coefficient Beta (b) was provided in the multiple analyses.

Results

Table 2 presents the means and standard deviations of CSAT's measures.

TABLE 2. Mean and standard deviation of CSAT's hits, commissions, reaction time, d' and A' by age group and gender.

	Boys		*Girls*		*Total*	
Age group	M	SD	M	SD	M	SD
Hits						
1st	58.63	11.76	56.01	11.65	57.59	11.76
2nd	70.32	8.44	65.32	9.58	68.20	9.25
3rd	70.15	8.53	73.67	9.76	71.64	9.19
4th	77.20	8.15	76.69	8.82	76.96	8.44
Commisions						
1st	44.53	22.63	39.66	25.53	45.59	23.88
2nd	27.27	14.63	24.63	13.24	26.15	14.07
3rd	28.68	15.83	26.30	18.77	27.68	17.08
4th	19.42	11.84	16.78	11.11	18.18	11.54
Reaction time						
1st	384.71	65.93	431.90	52.47	403.53	65.04
2nd	371.74	71.28	395.91	64.19	381.91	69.20
3rd	331.08	51.99	370.66	54.07	347.93	56.17
4th	342.44	55.11	382.16	59.98	361.05	60.60
d'						
1st	.21	.29	.23	.30	.21	.30
2nd	.51	.19	.48	.19	.50	.19
3rd	.49	.20	.56	.26	.52	.22
4th	.66	.18	.68	.18	.67	.18
A'						
1st	.64	.21	.65	.21	.65	.21
2nd	.83	.09	.81	.09	.82	.09
3rd	.82	.10	.85	.10	.83	.10
4th	.89	.07	.90	.07	.90	.07

Note. d' and A' standardised scores range from 0 to 1; in the case of A' the direct score range from 0.5 to 1, but CSAT apply a variable change (A' = 1-A') when comission proportion is higher than hits proportion.

An analysis of variance (ANOVA) was carried out on the subjects (age *x* gender) for each variable. The interaction effects was not significant in any case, and the gender factor considered separately was only significant in the case of the reaction time ($F_{(1, 576)} = 51.86$, $p < .01$), as the boys were faster than the girls at all ages. As to the age group factor, there was a significant difference in hits ($F_{(3, 576)} = 115.85$, $p < .01$), errors of commission ($F_{(3, 576)} = 52.03$, $p < .01$), reaction time ($F_{(3, 576)} = 25.14$, $p < .01$), d' ($F_{(3, 576)} = 109.08$, $p < .01$) and A' ($F_{(3, 576)} = 96.46$, $p < .01$). The reaction time variable was the only factor that did not show inequality of variances among the groups. Scheffé's *post-hoc* contrasts were then applied, revealing significant differences among all the groups, except between the third and fourth. On the other four variables, a Kruskal-Wallis analysis was applied, which was significant for hits ($\chi^2_{3} = 212.11$, $p < .01$), commission errors ($\chi^2_{3} = 116.43$, $p < .01$), d' ($\chi^2_{3} = 210.88$, $p < .01$) and A' ($\chi^2_{3} = 210.54$, $p < .01$). The group-to-group comparison by means of the Mann-Whitney *U* test (accepting a $p < .01$) showed identical results for all the variables: the four age groups can be reduced to three, given the lack of differences between the second and the third. In the case of hits, this lack of difference was due to a slim margin ($U = 5921.50$, $p = .01$), and it was far more obvious in commission errors, d' ($U = 6989$, $p = .41$) and A' ($U = 6939.50$, $p = .36$).

Table 3 shows the results of the reliability test. Data shows the reliability of the hits to be higher than commission errors and reaction time, and although some differences can be seen in the three measures according to age group, reliability is never lower than .59, and even exceeds .70 in eight of the indices (four of the hits, one of commission errors, and three of reaction time).

TABLE 3. Test-retest reliability of CSAT's hits, commissions, and reaction time.

Age group	*n*	*Hits*	*Commisions*	*Reaction time*
1st	36	.77	.59	.73
2nd	36	.69	.60	.66
3rd	36	.73	.62	.85
4th	36	.76	.88	.79
Total	144	.80	.61	.67

Table 4 shows the correlations between CSAT variables and the teachers' scales of academic performance, inattention and hyperactivity. The data in the table only reflect significant correlations and those greater than .20 (the reaction time is not described, as it did not present any significant value). Given the palpable substantially higher correlations in the older children, two subgroups were formed for the regression analysis: subgroup 1 comprised children from the first two age groups ($n = 320$), and subgroup 2 consisted of the others ($n = 191$). In subgroup 1 the multiple regression analysis of

the hits and commission error variables over the academic performance yielded a R^2 = .10, with b (hits) = .23 ($t_{(318)}$ = 4.08, $p < .01$) and b (commission) = -.14 ($p < .05$). The values were lower for the inattention scale (R^2 = .04) and lower still for the hyperactivity scale (R^2 = .00). In the case of inattention, b (hits) = -.15 ($t_{(318)}$ = -2.55, $p < .05$) and b (commission) = .10 ($t_{(318)}$ = 1.73, *ns*). The b coefficient of hyperactivity measure was no significant. The simple regression analysis of d' and A' over the scales produced the following results: in the case of academic performance R^2 (d') = .08 (F = 29.51, $p < .01$) and R^2 (A') = .07 (F = 23.77, $p < .01$). In the case of inattention R^2 (d') = .03 (F = 13.25, $p < .01$) and R^2 (A') = .03 (F = 10.19, $p < .01$). In the case of hyperactivity there was no significant value for R^2.

In subgroup 2, the multiple regression analysis that assessed the influence of hits and commission errors on the academic performance presented an R^2 = .14, with b (hits) = .37 ($t_{(189)}$ = 4.97, $p < .01$) and b (commission) = -.05 (*ns*). In the case of inattention, R^2 = .12, with b (hits) = -.33 ($t_{(189)}$ = -4.46, $p < .01$) and b (commission) = .07 (*ns*). In the case of hyperactivity, R^2 = .02 (*ns*). The simple regression analysis of d' and A' over the scales yielded the following results: in the case of academic performance R^2 (d') = .10 (F = 20.80, $p < .01$) and R^2 (A') = .08 (F = 17.29, $p < .01$). In the case of inattention, R^2 (d') = .09 (F = 20.50, $p < .01$) and R^2 (A') = .07 (F = 16.33, $p < .01$). In the case of hyperactivity, the values of R^2 were not significant for either d' or A'.

TABLE 4. Correlations between CSAT measures and teachers' scales.

	Hits	*Commision*	*d'*	*A'*
1st (*n* = 180)				
inattention	-.21**	.20*	-.25**	-.24**
overactivity				
achievement	-.26**	-.20*	.28**	.25**
2nd (*n* = 145)				
inattention	-.30**	.23*	-.32**	-.32**
overactivity				
achievement	.26**	.20*	.28**	.27**
3rd (*n* = 93)				
inattention	-.31**		-.25*	-.20*
overactivity				
achievement	.35**	-.24*	.34**	.30**
4th (*n* = 98)				
inattention	-.38**	.26*	-.36**	-.36**
overactivity				
achievement	.45**		.34**	.35**
Total (*N* = 516)				
inattention	-.21**		-.21**	
overactivity				
achievement	.24**		.24**	.21**

Note: only significant and .20 or higher values are included.
* $p < .05$, ** $p < .01$

Discussion

As regards the first objective of this study, it is safe to say that the CSAT is affected by age, as children grew older all measures improved, as in Conners' CPT analysis were found (Conners *et al*., 2003) with older subjects (9-17-year-old). To be more precise, two cutoff points were detected, the first at around seven and a half years

of age and the second at around nine and a half years of age. Thus, the CSAT performance measures have formed three groups of children: those that could be placed at the level of the first grade of elementary school, those of the second and third grades, and finally those of the fourth grade. The reaction time is the only measure that suggested any exception, as it levelled off at approximately age nine and a half. In this sense, we can confirm that the age interval for which the CSAT was designed appears to be adequate, although the scoring could only be standardised for three, rather than four age groups. Unlike Conners *et al.* (2003) study, no gender differences were found. It is possible that such differences could be more obvious from the preadolescence.

As regards our second objective, which centres on reliability analysis, the results are quite positive. These types of studies are not particularly common in CPTs or similar tasks, but the Conners' CPT-II is an exception (Conners, 2000): split half reliability (n = 520) range between .73 and .95, and test-retest reliabilities (n = 23) for a 3-moth interval range between .55 and .84. According to Conners *et al.* (2003, p. 557), "*both indices suggest adequate reliability for a neuropsychological test*". In our case, we don't know the split half reliability of the CSAT, but its test-retest reliability (n = 144) for a 7-9-days interval range is around .80 for hits/omissions, .61 for commission errors, and .59 for reaction time; that is, the results are very similar to CPT-II.

Our third objective, which is centred on some construct validity aspects of the CSAT, has also produced interesting results. If we leave out the reaction time, the other measures are far more related to those of the inattention and academic performance scales (as was hypothesised) than to motor overactivity, although some clarifications are necessary. First of all, the correlations are more frequent in the two older groups, and secondly, they are higher for hits and for both SDT statistics than for commission errors. Hence, the hits, d', and A' of the older children have allowed us to predict approximately 12% of their attentional behavior and 10% to 14% of their academic performance. In the younger children, while the levels may drop to around 7% they continue to be significant.

In short, we can conclude that the CSAT yields acceptable psychometric values. The descriptive statistics obtained here, based on a large sample of children, are encouraging for their use as normative data for comparison both normal and clinical sample, although further studies of convergent, discriminant, and predictive validity are required. If Epstein *et al.* (2003) founded overall significant relationships between CPT-II performance measures and ADHD symptoms, our results follow the same direction. CSAT hits, and commision errors to a lesser extent, as well as its SDT statistics had showed some implications on teacher scales, specially on inattention and achievement measures. In that respect we must point out that the nonparametric index A', which has proven to be an attentional capacity measure comparable to the more well-known d', has the advantage that it can be applied both to samples with normality assumption like ours and to others without this assumption, which are usual in clinical settings or applied studies.

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