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ORIGINAL RESEARCH

Detection of Sluggish Cognitive Tempo with d-CPT in children with ADHD

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Abstract

Objective: Considering the clinical presentation of sluggish cognitive tempo (SCT), the continuous performance test (CPT) that reveals the ability to maintain alertness and sustained attention is assumed to be impaired in children with attention deficit hyperactivity disorder (ADHD) accompanied by SCT. This study aimed to evaluate the distracted Continuous Performance Test (d-CPT) for SCT symptoms in children with ADHD.

Methods: Among 682 patients aged 7 to 12 years who were evaluated with attention problems between March 2019 and April 2020, a total of 46 patients meeting the inclusion and exclusion criteria were included in the study. The diagnosis of ADHD was made by a specialist child and adolescent psychiatrist using the family and teacher scales. Twenty patients were found to meet at least six items of the Barkley Sluggish Cognitive Tempo Scale–Children and Adolescents (BSCTS-CA), and SCT was accepted to accompany ADHD diagnosis in these children, so they were included in the ADHD+SCT group. Twenty-six patients were included in the ADHD group. The d-CPT tests were administered to both groups.

Results: The groups were similar in terms of age, gender, sociodemographic characteristics, and medical history. In the scale data of the ADHD + SCT group, inattention symptoms were found to be significantly higher, to demonstrate significantly poor performance in the "timing" sub-measurement in the d-CPT test battery, and the "timing" sub-measurement was found to significantly differentiate the ADHD + SCT group (AUC: 0.79, sensitivity 85.0%, specificity 66.4%).

Conclusion: The present study showed that there might be differences in neurocognitive functions of patients with SCT+ADHD compared to those with ADHD alone. In patients diagnosed with ADHD, SCT diagnosis should also be considered by clinicians, particularly when an impairment is observed in the timing subscale.

Keywords: Sluggish Cognitive Tempo, d-CPT, ADHD

INTRODUCTION

Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder characterized by inattention, excessive activity, or impulsivity, which are inconsistent with the level of development (1). Sluggish Cognitive Tempo (SCT) is characterized by excessive daydreaming, confusion, absent-mindedness, drowsiness, getting lost in own thoughts, and slow thinking and responding (2). Although there are no formal diagnostic criteria for SCT, the presence of frequent symptoms that lead to impaired functionality in at least one domain, which is determined with the help of scales, suggests the diagnosis of SCT. Besides the scales for ADHD symptoms, scales that assess SCT symptoms can be useful at this stage. In a study, marking three or more symptoms out of twelve symptoms as "often" or "very frequent" by the parents in the Barkley Child Attention Questionnaire (BCAS) and impairment of functionality by these symptoms in at least one domain was found to be significant in terms of SCT diagnosis (3).

In some studies, SCT has been reported as an inattention subtype of ADHD (2). However, when studies are reviewed, ADHD and SCT are observed to be two separate but associated disorders (4). This association is similar to the one between depression and anxiety disorders and

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the one between two disorders that are not subtypes of each other but are frequently seen together. In a study, 59% of the children who met the SCT diagnosis criteria were observed also to have ADHD, and this association was found to be particularly more common in ADHD inattentive type. Similarly, SCT symptoms can be present in 27–39% of children and adolescents diagnosed with ADHD (5). However, the correlation of SCT symptoms within themselves is greater than the correlation with ADHD symptoms (6). Contrary to the idea that SCT is a subtype of ADHD, SCT is not a reflection or expansion of ADHD, but an independent symptom cluster.

The literature review has shown that the relationship of SCT with neuropsychological functions has not been sufficiently investigated. In a study conducted in 2002, patients with ADHD accompanied by SCT were observed to have a lower speed in two neuropsychological motor tasks (7). Another study showed that the decrease in responding time as perceptual load increases in goal setting test was not normal in children with ADHD+SCT. With this result, researchers showed that children with ADHD + SCT had abnormal early selective attention and that this abnormality was not a characteristic of the ADHD subtype defined in the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) (8). In a study, children with high SCT scores were shown to demonstrate poor performance in tasks that indicate attention networks, such as working memory and reaction time, whereas impairments in tasks such as alertness and orientation were not associated with SCT. Attention networks were suggested to differ from ADHD (9). In a different study examining ADHD symptoms, SCT was found to be associated only with sustained attention. The authors concluded that SCT was an impairment in the alertness and disorientation functions, and its symptoms were not associated with executive functions (10). In a recent study where preschool children were graded by their teachers, higher SCT symptoms were found to be associated with poor performance regarding auditory and visual attention, as well as selective and sustained attention (11).

MOXO-CPT is an online test that measures the four main symptoms of ADHD: attention, Timing, impulsivity, and hyperactivity. It provides a clear, measurable, and objective assessment of the patient's performance over time. Considering the clinical presentation of SCT, impairments have been assumed to be observed in CPT results, which reveals the ability to maintain alertness and sustained attention in children with ADHD accompanied by SCT. This study aimed to assess SCT symptoms using d-CPT in children with ADHD.

METHODS

Among 682 patients aged 7 to 12 years who were evaluated with attention problems between March 2019 and April, 2020 examined retrospectively, a total of 46 patients meeting the inclusion and exclusion criteria were reached. These patients were invited to the Sakarya Child and Adolescent Psychiatry Institute and the diagnosis of ADHD was made by a specialist child and adolescent psychiatrist using the family and teacher scales. Twenty patients were found to meet at least six items of the Barkley Sluggish Cognitive Tempo Scale–Children and Adolescents (BSCTS-CA), and SCT was accepted to accompany ADHD diagnosis in these children, so they were included in the ADHD+SCT group. Twenty-six patients were included in the ADHD group. Both groups completed MOXO d-CPT Test. The inclusion criteria of the study were being within the age range of 7 to 12 years and being diagnosed with ADHD clinically and based on scales. Those who were receiving or received psychiatric treatment, children with anxiety disorder, depressive disorder, mood disorders, learning disorder, mental retardation, and neurological disorders, and those with autism spectrum disorder were excluded from the study. Other medical diagnoses including allergies, asthma, irritable bowel syndrome, chronic urticaria, and psoriasis were added as variables in medical illnesses to compare between groups.

Schedule for Affective Disorders and Schizophrenia for School-Age Children – Present and Lifetime Version (K-SADS-PL): It is a semi-structural interview form that can be applied to children aged 6 to 18 years. It was developed by Kaufman et al. (12) to determine the past and present psychopathology of children and adolescents according to the DSM-III-R and DSM-IV diagnostic criteria. The Diagnostic Screening Interview evaluates up to 200 symptoms and behaviors. This form, which is filled through interviews made with parents and children, includes various questions and evaluation criteria to evaluate each symptom. In cases where some symptoms are found to be positive with the screening interview, additional scoring is made in five diagnostic areas (Affective Disorders, Psychotic Disorders, Anxiety Disorders, Behavioral Disorders, Substance Abuse, and Other Disorders) to confirm the diagnosis. There are criteria to assess current (CE) and most severe past (MSP) episodes of the disorder in each list of symptoms. The validity and reliability study of the Turkish version of

K-SADS-PL was conducted by Gokler et al. (13). The level of agreement (consensus validity) between the clinical diagnoses made by the child and adolescent psychiatrists according to the DSM-IV criteria and diagnoses made as a result of interviews made using K-SADS-PL was found to be statistically significant.

Turgay DSM-IV-Based Child and Adolescent Disruptive Behavioral Disorders Screening and Rating Scale (T-DSM-IV-Scale): The scale was developed by Atilla Turgay according to the DSM-IV criteria (14). It consists of nine items for inattention, six items for hyperactivity, and three items for impulsivity. In the scale, the DSM-IV criteria were converted into a question form without changing their meanings. Each item is scored between 0–3 points. For the ADHD diagnosis, 2 or 3 points are required to be obtained from at least six items questioning attention deficit and at least six of the items questioning hyperactivity and impulsivity. A score of 2 or 3 points on at least four of six items is considered the criterion for diagnosing oppositional defiant disorder. In contrast, a score of 2 or 3 points should be attained on at least three of 15 items and lasted at least six months for a behavioral disorder. Ercan et al. conducted the Turkish validity and reliability study of the scale in 2001 (15).

Barkley Child Attention Scale (BCAS): The scale was developed by Russell Barkley in 2013 to measure SCT symptoms (3). The Turkish validity and reliability study of the scale was conducted by Baytunca et al. among children with ADHD. The four-point Likert-type scale consists of 12 items and two subscales: sluggishness and daydreaming. Each SCT item is scored as follows: 1: never or rarely, 2: sometimes, 3: often, and 4: very often. The sluggishness subscale consists of a total of seven symptoms, including decreased activity, lethargy, and slowness of behavior. In comparison, the daydreaming subscale consists of a total of five symptoms, including daydreaming, absent-mindedness, and mental confusion (10). The scale can be filled out either by the teacher or the parent. Obtaining 3 points or more from any item is considered significant for that item. Furthermore, Barkley considered a score of 3 points or more on at least three of 12 SCT symptoms as significant for SCT diagnosis. In a study from Turkey, meeting at least six items was used as the cut-off value for SCT diagnosis (10). The internal consistency (Cronbach's alpha) of the BCAS was calculated to be 0.984, and the test-retest reliability was found to be r = 0.84 (3).

MOXO d-CPT Test: MOXO d-CPT is an online attention measurement test that includes visual and auditory distracting stimuli. It was developed for children aged 6-12 years and adults aged 13-60 years to help diagnose ADHD. As in other CPTs, the participant is asked to sustain attention over a continuous stream of stimuli and to respond as quickly as possible to the pre-specified target stimuli by pressing the space bar once and only once. The most important feature that distinguishes the MOXO test from other CPTs is the measurable distractors. The test consists of eight stages. Each stage consists of a total of 53 stimuli (target or non-target visuals). Of the 53 stimuli presented, 33 are target stimuli, and 20 are non-target stimuli. Each stage lasts 114.15 seconds, and the total duration of the test is 15.2 minutes. Each stimulus is presented in the middle of the computer screen for durations of 0.5, 1, or 3 seconds.

The MOXO d-CPT includes four performance indices: attention, Timing, impulsivity, and hyperactivity. Attention corresponds to the number of correct responses during the stimulus presentation on the screen or during the void period that followed. Timing corresponds to the number of correct responses while the target stimuli are still presented on the screen. Impulsivity is the number of commission errors performed only during the time in which a non-target stimulus is present on the screen. Hyperactivity is the number of all types of commission responses that are not coded as impulsive responses. These sub-scales are examined at four levels by Z scores obtained from clinical groups (16, 17). The levels by Z scores are shown in Table 1.

Table 1. Impairment levels in ADHD subscales according to the MOXO d-CPT test

$Z \geq 0$	Level 1
$-0.825 \leq Z < 0$	Level 2
$-1.650 < Z \leq -0.825$	Level 3
$-1.650 \geq Z$	Level 4

Note: Z:Standart Score.

Statistical Analysis

Statistical processing and analysis of the data were performed using the SPSS statistics program for Windows version 21.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were expressed as mean (±) standard deviation, median (minimum-maximum), frequency distribution, and percentage. Visual (histogram and probability graphs) and analytical (Kolmogorov-Smirnov, Shapiro-Wilk tests) methods were used to determine whether the variables followed a normal distribution. The Student's t-test and Chi-squared tests were used for group comparisons. The

area under the curve values for ROC analysis were as follows: 0.90-1.00: excellent accuracy, 0.80-0.89: good accuracy, 0.70-0.79: fair accuracy, 0.51-0.69: poor accuracy, and 0-0.59: no discriminating ability. A p-value of <0.05 was considered statistically significant.

Ethical approval

Approval for the study was granted by the Sakarya University Ethical Committee with Approval no:71522473/050.01.04/257 dated 20.05.2020. All patients signed informed consent for participation in this study, and their anonymity is preserved.

RESULTS

A total of 46 patients were included in the study. The patients were divided into the ADHD+SCT group (n:20) and the ADHD group (n:26). There were no significant differences between age, gender, mother's and father's ages between groups. Also, there were no differences between the presence of the psychiatric history of the family, traumatic events, medical illnesses, and mother's medical problems in pregnancy. Table 2 presents the sociodemographic and clinical characteristics of the groups.

Table 2. Sociodemographic and clinical data of groups

Study Parameter		ADHD + SCT (n:20)	ADHD (n:26)	Statistics	p
Age		10.6±1.9	9.7±2.0	T:1.022	0.312
Gender	Male	70.0% (n:14)	61.5% (n:16)	χ2:0.357	0.390
	Female	30.0% (n:6)	38.5% (n:10)		
Mother's age		38.7±4.9	38.0±4.4	T:0.462	0.646
Father's age		41.4±5.2	40.5±5.2	T:0.565	0.644
Family Structure	Nuclear family	80.0% (n:16)	76.9% (n:20)	χ2:1.012	0.798
	Extended	15.0% (n:13)	11.5% (n:3)		
	Separated	5.0% (n:1)	11.5% (n:3)		
Presence of psychiatric disorder history in the family		10.0% (n:2)	0.0% (n:0)	χ2:2.718	0.257
Presence of traumatic event history in the family		15.0% (n:3)	19.2% (n:5)	χ2:0.141	0.707
Presence of medical illness in the children		15.0% (n:3)	15.4% (n:4)	χ2:0.010	0.917
Medical problem during pregnancy		30.0% (n:6)	38.5% (n:10)	χ2:0.357	0.390

Note: χ2:Chi-Squared test; T:Student's t-test. p value of <0.05 was considered statistically significant and is shown in bold.

Turgay inattention scores (T:2.549, p:0.020, Cohen's d:0.519) and BACS scores (T:5.262, p:0.001, d:2.214) of the ADHD+SCT group were found to be statistically significantly higher than those of the ADHD group. Hyperactivity scores were not different between groups (T:1.438; p:0.122). The scale data are shown in Table 3.

Table 3. Comparison of attention scale data of groups

Study Parameter		ADHD + SCT (n:20)	ADHD (n:26)	Statistics	p	Effect Size
Turgay Parent Form	Inattention	18.1±4.5	15.6±5.1	T:2.539	**0.020**	d:0.519
	Hyperactivity/Impulsivity	14.2±4.9	15.7±3.2	T:1.438	0.122	-
Barkley Child Attention Scale		27.2±3.9	19.4±3.1	T:5.262	**0.001**	d:2.214

Note: d: Cohen's d; T:Student's t-test. p value of <0.05 was considered statistically significant and is shown in bold.

The MOXO d-CPT timing scores of the ADHD+SCT group was found to be statistically significantly higher (Z:3.518, p:0.001, η^2:0.269), and by the cut-off point, ADHD+SCT group Timing problems were significantly higher than the ADHD group (χ2:8.065, p:0.005, Φ:1.189). Table 4 presents the comparison of the d-CPT scores of the groups.

Table 4. Comparison of d-CPT scores of the groups

Study Parameter		ADHD+SCT (n:20)	ADHD (n:26)	Statistics	p	Effect Size
Severity	Attention	Median:2 IQR:3	Median:1 IQR:2	Z:1.508	0.132	-
	Timing	Median:4 IQR:1	Median:2 IQR:2	Z:3.518	**0.001**	η^2:0.269
	Inattention	Median:4 IQR:1	Median:2 IQR:3	Z:1.569	0.117	-
	Hyperactivity	Median:1 IQR:2	Median:1 IQR:3	Z:0.412	0.680	-
By cut-off point	Attention	35.0% (n:7)	15.4% (n:4)	χ2:2.391	0.116	-
	Timing	60.0% (n:12)	19.2% (n:5)	χ2:8.065	**0.005**	Φ:1.189
	Inattention	15.0% (n:3)	30.8% (n:8)	χ2:1.545	0.187	-
	Hyperactivity	15.0% (n:3)	26.9% (n:7)	χ2:0.945	0.273	-

Note: χ2:Chi-Squared test; η^2:Eta-Squared; Φ:Cramer's phi; Z:Mann-Whitney U test. p value of <0.05 was considered statistically significant and is shown in bold.

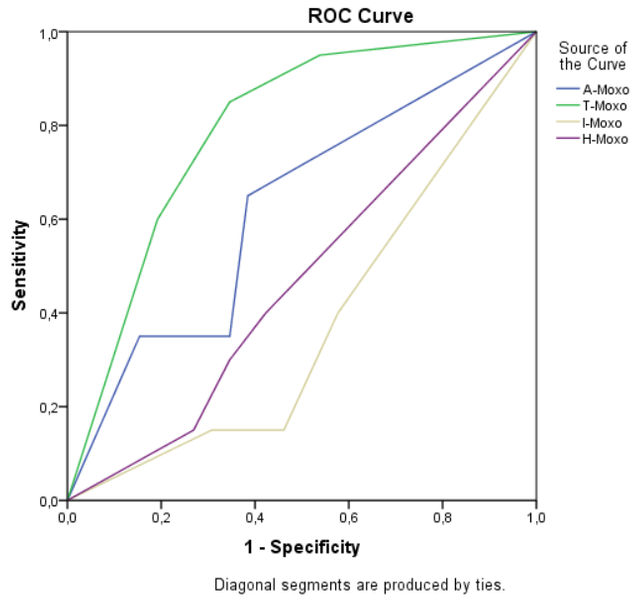
When ROC analysis was performed for the distinction between ADHD + SCT and ADHD groups by the d-CPT subscales, the timing subscale was found to be statistically significant in the distinction of the groups (AUC:0.792, p:0.001). Table 5 shows the ROC curves data, and Figure 1 shows the ROC curve.

Table 5. ROC analysis of d-CPT subscales in respect of detecting ADHD+SCT patients in study group

Parameter		AUC	CI	p	Sensitivity	Specificity
Severity	Attention	0.621	0.456-0.785	0.164	65.0%	61.5%
	Timing	0.792	0.660-0.924	**0.001**	85.0%	66.4%
	Inattention	0.374	0.211-0.537	0.147	40.0%	42.3%
	Hyperactivity	0.468	0.300-0.637	0.715	40.0%	58.7%

Note: AUC: Area Under Curve; CI: Confidence Interval. p value of <0.05 was considered statistically significant and is shown in bold.

Figure 1. ROC curve of d-CPT subscales in respect of detecting ADHD+SCT patients in study group



DISCUSSION

A total of 46 patients were included in the present study. There were no significant differences between the groups in terms of age, gender, sociodemographic characteristics, and medical history. In the scale data of the ADHD + SCT group, inattention symptoms were found to be significantly higher, to demonstrate significantly poor performance in the "timing" sub-measurement in the d-CPT test battery, and the "timing" sub-measurement was found to significantly differentiate the ADHD + SCT group (AUC: 0.79, sensitivity 85.0%, specificity 66.4%).

The Turgay Parent Form inattention subscale scores and BACS scores of the ADHD + SCT group were found to be significantly higher than those of the ADHD group. The results of the present study seem to be consistent with the literature. Several studies have reported that the rate of SCT symptoms is 30-63% in cases with the attention-deficit dominant type of ADHD. (18-20) In a meta-analysis on SCT evaluating numerous variables, SCT was concluded to be different from ADHD, and there was a need for further studies to understand the structure of SCT. (21) In light of the results obtained, when attention deficit dominant type is identified in scales questioning ADHD, auxiliary scales should be applied to help diagnosis, and clinical evaluation should be made for SCT.

The d-CPT timing scores of the ADHD+SCT group were found to be higher compared to the ADHD group, whereas no statistically significant difference was observed between the groups in terms of attention, inattention, and hyperactivity scores. This result suggests that the ADHD + SCT group is slower in tasks assigned in accordance with their clinical picture. In a recent study comparing SCT+ADHD, ADHD, and control groups, the performance of the SCT+ADHD group was found to be lower than the control group in all areas, whereas their

performance was found to be lower, particularly in commission error and reaction time compared to ADHD group. In this study, CPT reaction time was observed to remain significant in the regression analysis, in which the Shifting Attention Test (SAT) results were included considering that the ability to maintain alertness of individuals with SCT symptoms may be impaired, and SAT correct response and CPT commission error were observed to become insignificant (10). In several studies, "slow-moving" and "under-responsive," characteristics of youth diagnosed with SCT are defined as separable from both inattention and other characteristics of SCT, such as day-dreaminess and low initiation/poor persistence (22).

In the present study, impairments were observed in d-CPT measuring continuous attention, which was consistent with previously conducted SCT studies (23). Furthermore, the long reaction times of the ADHD + SCT group suggest that they also have problems in ensuring and maintaining alertness. This result is further consistent with Posner's theory of attention, which suggests that the alertness component of attention plays a role in ensuring and maintaining the alertness required to complete a particular task (24). Similarly, other studies have shown that parental scores and lower performance in sustained attention in CPT have a significant correlation after controlling for symptoms of inattention and hyperactivity, whereas they were not correlated with naming speed, combined processing speed, and response inhibition scores (25). A recent study has shown that 183 children aged between 7 and 10 years from primary schooles completed the Attentional Network Test ANT and an n-back task, and their parents completed an SCT-Child Behavior Checklist, and after controlling sociodemographic variables, SCT symptoms were correlated with lower scores on both tests, with slower reaction times on the Attentional Network Test (26).

Our study has limitations in evaluating SCT in children with ADHD. Those with SCT comorbid to ADHD, although they did not have other psychiatric disorders clinically, could have features that could be measured, such as subthreshold depression and learning problems, and could affect neuropsychological performance. Also, although there were no mental problems clinically, a standard intelligence measure could explain the difference between ADHD and ADHD-SCT. Making these evaluations in future studies will help to understand the place of SCT in ADHD. Ecological validity and the "real-life" meaning of SCT has contradictory scientific supports in literature. Tamm et al. (27) investigated these SCT affects academic performance and reported significant correlations between parent-rated SCT scales and academic achievement. Results showed that higher SCT (especially slowness) symptoms were associated with poorer grades, as well as impairments in homework completion, planning, writing skills, and overall academic outcome, even when controlling for ADHD symptoms. Langberg et al. (28) shown parent-rated SCT Slow subscale predicted overall academic functioning, organizational skills impairment, and homework problems above and beyond ADHD symptoms on 52 adolescents. Most of these studies were based on school grades and rating scales, clinical diagnosis effect on academic performance still lack in current literature. This aspect should be taken care of in future studies, clinical, neuropsychological, and real-life data (academic grades, teacher reports) should be analyzed.

CONCLUSION

The present study showed that there may be differences in neurocognitive functions of patients with SCT+ADHD compared to those with ADHD alone. In patients diagnosed with ADHD, SCT diagnosis should also be considered by clinicians, particularly when an impairment is observed in the timing subscale.

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