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Dynamic occupation assessment of executive function in adolescents with schizophrenia spectrum disorders: An initial report

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ABSTRACT

Objective: This study presents an initial evaluation of the psychometric properties of the Dynamic Occupation Assessment of Executive Function (DOAEF), a new tool designed to assess adolescents' executive function (EF) in daily situations and offering two levels of mediation through the administration process.
Method: In the preliminary study, we tested 22 healthy adolescents. In the advanced stage, the instrument was administered to 105 healthy adolescents and to another 92 adolescents diagnosed with schizophrenia spectrum disorders. Information regarding EF was assessed by the DOAEF and Wisconsin Card Sorting Computer Version Test (WCST-CV-64).
Results: Inter-rater, test–retest and internal consistency indices were found to be satisfactory. Correlation between the DOAEF and the WCST-CV-64 scores supports the DOAEF's convergent validity. Significant differences were found between the healthy participants and the adolescents diagnosed with schizophrenia spectrum disorders, thus supporting the DOAEF's criterion validity.
Conclusion: The DOAEF may be useful in assessing the level of mediation, which patients need for the comprehension of daily situations in which EFs are required.

1. Introduction

1.1. General background

The term executive function (EF) refers to a multidimensional construct that describes a set of cognitive abilities that regulate and control behavioral, cognitive and emotional responses [35]. EFs consist of mental flexibility, working memory, prediction, goal positioning, problem resolution, self-control and self-correction [14]. Independent functioning requires the ability to set goals, make decisions and use judgment and self-correction while performing daily living activities [12]. The development of EF skills starts in infancy and continues throughout adolescence and adulthood.

1.2. Implications in adolescence

Adolescence is a critical period for the maturation of neurobiological processes that underlie high cognitive, social and emotional behaviors [34]. Several aspects of development during this period are especially significant in this regard. Among them is the role of puberty in the significant restructuring of many body systems and its influence on social information processing. The latter is expressed in the apparent concentration of changes in the adolescent brain in the prefrontal cortex (which serves as a governor of cognition and action) together with the enhanced interregional communication between the prefrontal cortex and other brain regions and the evidence for substantial synaptic pruning and for non-trivial physiological reversibility of behavioral and neuroendocrine patterns arising from early developmental experiences [31]. It is noteworthy that substantial reorganization of the neural systems underlying EF takes place during adolescence. In the early stages of adolescence, developmental processes

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lead to significant advances in cognitive flexibility, goal setting and information processing abilities [3]. The ability to maintain and manipulate multiple spatial units develops by the time the child reaches 13 to 15 years [25]. Strategic self-organization develops later on, during mid-adolescence (ages 16 to 17 years) [25] and in late adolescence (18–21 years) an improvement is seen in nonverbal working memory tasks with varying levels of executive demands [25]. In summary, the ability to perceive multidimensional concepts and thus to be able to think in a more strategic manner improves during adolescence [8]. Recent literature has distinguished between cool EF that involves the execution of these processes under relatively neutral conditions, and hot EF that occur in emotionally salient contexts that may also require risk and reward processing. Cool and hot aspects of EF show protracted maturation across development and may contribute to real-word behavior in different and overlapping ways [35]. The development of an integrated and consciously controlled "executive suite" of regulatory capacities is a lengthy process and a fully coordinated set of EF occurs later in development [31].

Severe impairment in some of these functions was found to be associated with psychotic conditions and especially with schizophrenia spectrum disorders [13,21,24]. Adolescents diagnosed with schizophrenia spectrum disorders (ADSSD) display significant deterioration in working memory, logical memory, conceptualization and verbal-visual learning [20]. Deterioration in visual memory, abstraction and mental flexibility has also been described in the literature [27].

The relationship between impairments in EF and difficulties in daily autonomous functioning in ADSSD is well documented [5,7,29]. The ADSSD were found to have trouble with academic functioning, coping with situations that require problem solving, shifting from one activity to another, setting priorities, time perception and initiation of new tasks [5]. Additionally, EF impairments were found to be related to interruption of social interactions, thus creating difficulties in behaving according to social norms [7,29].

1.3. Currently used tools for EF assessment in adolescents

Several instruments exist for the assessment of EF among adolescents. The most commonly used one is the Wisconsin Card Sorting Test (WCST) [18], which assesses mental flexibility and abstraction. Another neuropsychological instrument is the Verbal Fluency Test (VFT) [23], which estimates the ability to implement verbal strategies. The Stroop Task [15], assesses response inhibition and selective attention, while the Self-Ordered Pointing Task (SOPT) assesses working memory requiring the ability to generate and monitor a sequence of responses [28] and the Tower of London (TOL) [2] assesses planning ability and immediate memory in children and adolescents. The Measurement and Treatment Research to Improve Cognition in Schizophrenia (MATRICS) is a standard battery of tests used in populations of ADSSD, to evaluate six out of seven neurocognitive domains: processing speed, concentration, working memory, verbal and visual learning and problem solving [16,19]. The validity of all these methods is well documented [19]; they do not however, assess EF directly, in the context of social cognition and daily functioning. The Behavioral Assessment of Dysexecutive Syndrome (BADS) was designed to assess various EF using tasks that are part of daily functioning [9] and require using various executive abilities (e.g., attention, working memory, planning, monitoring, self-correction and initiation). The Behavior Rating Inventory of Executive Function (BRIEF) [26] is an observation-based instrument, in which teachers and parents report behaviors that are expected to be impaired, as a result of executive dysfunctions. This inventory includes eight scales that assess specific behavioral components: inhibit, shifting, emotional control, initiate, working memory, plan/organize, organization of materials and monitoring.

1.4. Rational for the development of a new tool

Despite the fairly large variety of instruments in existence, in this realm, there does not seem to be a tool that allows dynamic assessment of EF in the context of daily functioning, among adolescents. This paper introduces a new diagnostic instrument, the Dynamic Occupational Assessment of Executive Function (DOAEF). The goal of the DOAEF is to enable clinical evaluation of executive dysfunctions among adolescent patients that display impairments and particularly patients in the schizophrenia spectrum.

The DOAEF has several advantages over the existing assessment tools. It was developed in order to assess EF in adolescents in the context of daily situations requiring decision-making and mental flexibility. The items of the test are therefore, tailored to suit situations and contents derived from the world of adolescents. In addition, most items require mental flexibility, which is an essential factor in problem solving among people diagnosed with these disorders. Finally, DOAEF was designed to be administered with several levels of mediation, thus providing a more accurate evaluation of the extent of impairment in the patient's EF. In our tool, the examiner utilizes a systematic approach to modify the task through mediation in order to understand the type of information that is essential to complete the task. The examiner could learn much about a patient's undetected abilities from the responses to such cues. In this way, dynamic assessment becomes naturally linked to intervention, and can be used as a baseline for choosing and designing an intervention program [32]. This enables the therapists to assess the influences of EF on adaptive occupational behavior in adolescence and this can be helpful in developing effective remediation strategies.

1.5. Description of the Dynamic Occupation Assessment of Executive Function (DOAEF)

The DOAEF is designed for occupational therapists to assess adolescents' EF. It contains 16 items describing functional situations requiring the application of EF. The situations were taken from the daily life of adolescents (see Appendix A for examples). Items were formulated in order to assess the clients ability to recognize the cause of everyday situations (3 items), the ability to generate various ways of solving functional problems (4 items), the prediction of outcomes of functional situations (5 items) and the ability to apply abstract reasoning by finding the common feature of two different situations (4 items). Participants are asked to respond to each item in their own words. If the participant's answer is wrong, a total of two levels of mediation are available. In the first level, participants are asked to choose the correct answer out of four and in the second level participants are asked to choose the correct answer out of two. Each item gets a score between 0 and 3, where 0 indicates a wrong answer despite all mediation levels, 1 indicates a correct answer with a high level of mediation, 2 indicates a correct answer with a low level of mediation and 3 indicates a correct answer with no mediation whatsoever. The overall score ranges from 0 to 48 points.

The initial version of the DOAEF was based on 20 items that were formulated following a review of the theoretical and empirical literature regarding EF. The contents of these items were reviewed by three experts in occupational therapy. Following their remarks, three items were rephrased and four items were dropped. The DOAEF was tested for reliability and validity. First,

inter-rater, test–retest and internal consistency reliability indices, as well as a convergent validity index, were calculated on a sample of 22 healthy adolescents. Then a criterion-based validity was established by comparing the DOAEF scores of two larger samples: healthy adolescents and ADSSD.

2. Subjects and methods

2.1. Sample and procedures

This was a cross-sectional study that was performed in 2 stages: a preliminary stage and an advanced stage. All participants in both stages were Hebrew-speaking adolescents from the Tel Aviv area in Israel.

2.1.1. Preliminary stage

In the preliminary study, 22 healthy adolescents aged 12–21 years (M = 17.82, SD = 2.56) were tested, 4 (18%) of them male and 18 (82%) female. None of them had a psychiatric background.

2.1.2. Advanced stage

In the advanced stage of the study, two groups of adolescents matched by age, education and gender were assessed.

2.1.2.1. The study group. The study group included 92 adolescents between the ages of 12–21 years (M = 16.83, SD = 2.01), 57 (62%) male and 35 (38%) female, who had been diagnosed with schizophrenia spectrum disorders according to the DSM-IV-TR [1] criteria. This group consisted of consecutive admissions to the adolescent inpatient unit of the Geha Mental Health Center during the years 2009 to 2013.

2.1.2.2. The control group. The control group consisted of 105 healthy adolescents between the ages of 12–21 years (M = 16.92, SD = 2.19) with no psychiatric background, 68 (64.8%) of them male.

Exclusion criteria included refusal by the adolescent's parents to sign the informed consent form, uncorrectable visual impairment, other organic diseases (such as movement disorders, epilepsy or mental retardation) and substance abuse.

2.2. Measurements

The study was approved by the Institutional Review Board. All participants and their parents signed an informed consent form, following an explanation regarding the nature of the study. Participants were assessed individually at their schools, in spaces that were quiet and free from distractions. It should be noted that while some of the participants in the study group were above normal school-age (which is 18 in regular schools), these youngsters were in the Israeli Special Education system that includes students up to 21 years of age. The assessment interview lasted for approximately 15 minutes.

In the first stage, the 22 healthy participants were administered the DOAEF and the computerized version of the Wisconsin Card Sorting Test Computer version (WCST-CV-64) [22]. In order to examine the test–retest reliability of the DOAEF, it was administered at the beginning of the study and again 2 months later. At the first administration, three independent raters, experts in occupational therapy, scored the participants' answers in order to check for inter-rater reliability. The reliability of the DOAEF was further examined by calculating indices of test–retest reliability and internal consistency. Convergent validity was established by investigating the associations between the DOAEF and four scores of the WCST-CV-64 (conceptual level responses [CLR], total correct [TC], completed categories [CC] and learning to learn [LL] at both points of time).

Criterion-based validity was examined in the second stage, by comparing the DOAEF scores of the control group of healthy participants ($n = 105$) with those of the ADSSD participants ($n = 92$).

2.3. Statistical analysis

Statistical analyses were conducted using an SPSS-19 complex sample analysis module (IBM-SPSS INC, Chicago, IL). Cronbach's alpha coefficients were used to assess internal reliability. Intra-class correlations (ICC) were used to assess inter-rater reliability. Pearson correlation and independent *t*-test were used to test the associations between the normal distribution variables. The Chi^2 tests were used to measure associations between the categorical variables. *P* level of less than 0.05 was considered significant. All tests were two-tailed.

3. Results

3.1. Preliminary stage

3.1.1. Relationship between demographic variables and DOAEF scores

Age and education were not found to be significantly correlated with the scores of the DOAEF, neither was a significant correlation found between age and education in either the first measurement ($r = -0.24$, $P = 0.197$ for age and $r = -0.27$, $P = 0.126$ for education) or the second one, namely the retest in the preliminary stage ($r = -0.30$, $P = 0.16$ for age and $r = -0.24$, $P = 0.119$ for education).

3.1.2. Inter-rater reliability

The results showed a very high inter-rater reliability. The results are presented in Table 1. As can be seen, the Pearson correlations between raters were found to be in the range of 0.69 to 1.00, 0.72–1.0, 0.81–1.0 (all $P < 0.001$) and intra-class correlations for all found to be in the range of ICC = 0.79; 95% CI: 0.63–0.90 to ICC = 0.99; 95% CI: 0.88–0.97. In addition, intra-class correlations for the questionnaire's total score were very high (ICC = 0.97; 95% CI: 0.94–0.99).

3.1.3. Test–retest reliability

A significant positive correlation was found between the first and the second measurement's total scores ($r = 0$ .91, $P < 0.001$).

Table 1
Inter-rater reliability for the DOAEFs items in healthy participants ($n = 22$).

Item	Pearson correlations between A, B. C ($P < 0.001$)			ICC (95% CI)
	A and B	B and C	A and C	
1	0.84	0.84	0.69	0.79 (0.63–0.90)
2	0.93	0.93	1.00	0.96 (0.91–0.98)
3	0.90	1.00	0.90	0.99 (0.88–0.97)
4	0.81	0.89	0.90	0.94 (0.88–0.97)
5	1.00	0.87	0.87	0.86 (0.75–0.94)
6	0.93	1.00	0.93	0.95 (0.91–0.98)
7	0.95	1.00	0.95	0.97 (0.93–0.98)
8	0.82	0.91	0.91	0.88 (0.78–0.95)
9	0.93	1.00	0.93	0.95 (0.90–0.98)
10	0.90	0.90	1.00	0.94 (0.87–0.97)
11	0.83	0.82	0.83	0.82 (0.68–0.91)
12	0.91	1.00	0.91	0.94 (0.88–0.97)
13	0.87	0.93	0.94	0.90 (0.81–0.95)
14	0.91	0.91	0.82	0.88 (0.78–0.95)
15	1.00	0.90	0.90	0.93 (0.87–0.97)
16	0.84	0.93	0.93	0.86 (0.74–0.93)

ICC: intra-class correlations; DOAEF: Dynamic Occupational Assessment of Executive Function.

Table 2
Pearson correlations between the DOAEF and WCST-CV-64 ($n = 22$).

WCST-CV-64 indices	DOAEF 1st assessment	DOAEF 2nd assessment
Conceptual level responses (CLR)	0.77**	0.69**
Total correct (TC)	0.73**	0.61**
Categories completed (CC)	0.52*	0.45*
Learning to Learn (LL)	0.14	0.20

DOAEF: Dynamic Occupational Assessment of Executive Functions; WCST-CV-64: Wisconsin Card Sorting Test Computer Version.
* $P < 0.05$.
** $P < 0.01$.

Table 3
Demographic variables in the study group and the control group ($n = 197$).

Variable	Study group ($n = 92$)	Control group ($n = 105$)	df	χ^2	P
Gender					
Boys	57 (62%)	68 (64.8%)	1	0.17	0.683
Girls	35 (38%)	37 (35.2%)			
Place of birth					
Israel	80 (87%)	85 (81%)	1	1.30	0.254
Not Israel	12 (13%)	20 (19%)			
Education level					
Elementary	7 (7.8%)	6 (5.8%)	3	3.74	0.291
Junior high	28 (31.1%)	24 (23.1%)			
Partial high school	40 (44.4%)	46 (44.2%)			
Full high school	15 (16.7%)	28 (26.9%)			

3.1.4. Internal consistency

The Cronbach's alpha index was 0.83.

3.1.5. Convergent validity

Convergent validity was explored by assessing the relationships between the DOAEF and WCST-CV-64 scores of the healthy participants at the two measurements. The results are presented in Table 2. As can be seen, positive correlations were found between the DOAEF total scores and all the WCST-CV-64 scores at both measurement times, except for the LL score.

3.2. Advanced stage

3.2.1. Between group comparison of demographic characteristics

Table 3 presents the distributions of the demographic variables in both groups. No significant differences were found between the study group and the control group in the distributions of gender, place of birth and education level. In addition, there were no significant differences between groups in the mean age, $t(195) = 0.325$, $P = 0.539$.

3.2.2. Criterion-based validity

After examining the internal consistency of the DOAEF in the whole group of participants ($n = 197$; Cronbach's alpha = 0.96), a t-test for independent samples was conducted in order to compare the DOAEF scores of healthy participants and ADSSD participants. The results are presented in Table 4. As can be seen, healthy adolescents performed significantly better than the ADSSD.

4. Discussion

This study examined the reliability and validity of the DOAEF. As shown in Table 1, in the current study, Pearson r for inter-rater reliability analyses ranged between 0.69 and 1.00, $P < 0.001$ for all items. These results are similar to inter-rater correlations in the BADS instrument (0.88–1.00, all $P < 0.001$) [9]. They are better, however, than the inter-rater correlations in the BRIEF assessment [14] between parents and teachers which are moderate (0.32–0.34, all $P < 0.01$). Regarding the ICC range, this study ranges between 0.79 and 0.99, while the WCST inter-scorer reliability coefficients range from 0.895 to 1.0 (with the exception of the Learning to Learn score) in children and adolescents [18].

Test–retest reliability of the DOAEF was found to be high ($r = 0.91$, $P < 0.001$) thus indicating that the DOAEF's scores have good stability over a period of two months [10]. The average teacher test–retest correlation in a normative sample was 0.87 ($P < 0.01$) over a period of 3.5 weeks in the school-age version of BRIEF [14]. In the TOL test, test–retest correlation in a clinical child sample was 0.80 ($P < 0.001$) over a period that ranged from 5 to 92 days [2]. In the BADS the test–retest analyses revealed mixed findings; correlations ranged between –0.08 and 0.71 over a period of 6–12 months, and only three were significant (all $P < 0.001$) [9].

Regarding internal consistency, our data show that Cronbach's alpha indices were 0.83 in the 22-participant sample, and 0.96 in the 197-participant sample. These results indicate a high internal consistency similar to that of the school-age parent-report version of BRIEF (Cronbach's alpha indices were from 0.80 to 0.98) and Adolescent BRIEFF-Self-Report (Cronbach's alpha indices were from 0.75 to 0.96) [14].

The convergent validity indices between the DOAEF and the WCST-CV-64 were moderate to high. Similarly, scores of the TOL test correlated moderately (from $r = 0.41$ to $r = -0.71$, all $P < 0.001$) with the subtests of the WCST for children [2]. The reason for the moderate indices that were found may be related to the fact that the DOAEF relates to daily behavioral aspects that are not represented in the WCST-CV-64.

Criterion-based validity was analyzed by comparing a group of ADSSD participants and healthy adolescents in order to examine whether the DOAEF succeeds in differentiating between them. The difference found between the ADSSD and the control group was significant (large Cohen's effect size 1.83, $P < 0.001$). This is in accordance with previous findings regarding the MATRICS [19] for Cohen's effect size (0.8–1.8, all $P < 0.05$) in patients with early-onset schizophrenia spectrum disorders and healthy controls. These results lead us to the assumption that the operating characteristics of the DOAEF are high and comparable to those of other instruments that are used for the assessment of EF in adolescents.

The correlations between the DOAEF and WCST-CV-64 scores were moderate, with the exception of the correlation between

Table 4
Means and SD of the DOAEF scores among adolescents who suffer from schizophrenia spectrum disorders and healthy participants.

	Adolescents who suffer from schizophrenia spectrum disorders ($n = 92$)		Healthy adolescents ($n = 105$)		$t(195)$, $P < 0.001$	Cohen's d
	M	SD	M	SD		
DOAEF scores	1.62	0.74	2.63	0.24	21.36	1.83

DOAEF: Dynamic Occupational Assessment of Executive Functions.

the DOAEF and the Learning to learn (LL) score, which was not significant. The latter finding may indicate that LL and EF do not overlap. Findings of previous studies support the differentiation between these two constructs [6,30]. For example, Ardila et al. [4] support the assumption that traditional intelligence tests do not assess EF properly. Duan et al. [11] did not find a significant association between two EFs, inhibition and shifting and between general intelligence. Other studies [6] found dissociated performance on the executive and associative learning tasks in first-episode psychosis. Similarly, a study [17] that analyzed the WCST performance reported the LL was not found significant relative to other scores. The results of these studies support our previous findings that EF and LL [24] constitute different skills in adolescents. LL does not show any developmental trends in contrast to EF. A possible reason may be that EF constitutes the ability to use one's knowledge creatively in order to solve problems while the typical tests measuring "learning" actually measure recall of previously learned facts.

This study has several limitations. The convergent validity of the DOAEF was examined only in relation to the WCST-CV-64. It might be useful to further investigate the relationship between the DOAEF scores and other instruments for measuring EF in adolescents. Another limitation of the study is the wide age range (12–21 years), which may cause heterogeneity of the sample as adolescence is a period of development and many neurocognitive developmental changes may occur. However, this is a preliminary study focusing on the correlation between the DOAEF and other cognitive tests. The current sample is not large enough to check trends within each age group. This will be dealt with in a future study using a larger sample. In addition, attention and concentration were not assessed in this study. Patients who suffer from schizophrenia spectrum disorders may suffer from impaired attention and concentration and this may be an alternative explanation for the differences found between them and controls. These issues require further investigation.

5. Conclusion

The present study indicates that the DOAEF may be a promising new instrument for the dynamic assessment of executive dysfunction in everyday performance among adolescents. The reliability and validity properties of the DOAEF were found to range between moderate and very high with the majority being at the very high level. The results show the DOAEF to be a diagnostic tool that can be used to reliably assess EF in adolescents who suffer from schizophrenia spectrum disorders. The strength of the instrument is in it being based on the concept of dynamic assessment in daily functioning and using tasks that require mental flexibility – a domain that is usually impaired in patients diagnosed with ADSSD. The DOAEF provides information on the level of mediation needed by the patient in order to comprehend daily situations requiring executive functioning thus aiding in the planning of specific treatment interventions and rehabilitation programs for the patient.

The results of this research show that occupational therapy has an important place in the study of EF and warrant further attention. More studies are needed in order to examine the developmental aspects of EF and life experiences among adolescents. We hope that this measurement of EF that links assessment with real-world behaviors of adolescents, will encourage further development of interventions, and enhance the independence of individuals with ADSSD. Additional studies are also required in order to replicate our findings in larger samples and investigate the suitability of the DOAEF for other populations.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

Appendix A. Some examples of items in the DOAEF

Identifying causes of various daily life situations: "Describe as many possible reasons as you can for the following situation: You come home and turn on the TV but nothing happens – the TV does not turn on."

Ability to generate a variety of solutions for daily life problems: "Describe as many solutions as possible to the following situation: you need a new wallet. It costs NIS 50 but you have only NIS 48. What do you do in order to acquire the wallet anyway?"

Prediction of outcomes of daily life situations: "Describe as many outcomes as possible to the following behavior: Habitually not preparing your homework."

Abstract reasoning: "Describe the similarities in the following two situations:

(1) You bought a new shirt, but at home, when trying it on you found it to be too small.
(2) You bought ice cream but didn't check the change till getting home. When counting it you discovered you were short–there was money missing."

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