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Comparison of executive functions in disruptive mood dysregulation disorder and attention-deficit hyperactivity disorder

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ABSTRACT

Objective: The aim of the current study was to compare the executive functioning of children with disruptive mood dysregulation disorder (DMDD) with matched groups of children diagnosed with ADHD and typically developing children (TD). Groups were matched in terms of age, gender, and IQ.

Methods: A total of 41 children aged 6–12 years old with DMDD (N = 11), ADHD (N = 15) and TD (N = 15) performed GO/NO-GO, N-Back, CPT tasks to assess executive functions of inhibition, working memory, and attention, respectively. Their parent completed BDEFS-CA.

Results: The analyses of variances indicated significant differences in all EF tasks between both groups of ADHD and DMDD and those of TD children. There were no significant differences between ADHD and DMDD children. In the Go/No-Go task, individuals with DMDD obtained greater scores in Commission error and Reaction times than ADHD and TD groups. In the N-back task, both DMDD and ADHD groups were similar, and they obtained less rate than typical individuals. While we found no significant differences in both ADHD and DMDD groups in the CPT task.

Conclusion: TD children outperformed all children diagnosed with DMDD and ADHD in all EF tasks.

Disruptive mood dysregulation disorder (DMDD) is a relatively new mental disorder recently added as a diagnostic category in the DSM-5 (Diagnostic and statistical manual of mental disorders DSM-5®, 2013). To determine the specificity of diagnostic issues this group of children is often different from children who shared bipolar disorder (BP) diagnosed during their childhood (Diagnostic and statistical manual of mental disorders DSM-5®, 2013). A key difference in DMDD individuals is irritability rather than BD (Wiggins et al., 2017). Indeed, DMDD is especially related to autism or other disorders in which DMDD symptoms are common. We addressed two core features such as unrelenting irritability or anger and temper outbursts to diagnostic for DMDD (Tourian et al., 2015). Whereas, the literature is lacking a thorough review of all aspects and symptoms of DMDD. The number of studies on DMDD determined a high and clear rate of comorbidity with the other psychiatric disorders such as attention-deficit/hyperactivity disorder

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(ADHD), oppositional defiant disorder (ODD), and conduct disorder (CD) (Diagnostic and statistical manual of mental disorders DSM-5®, 2013; Wang et al., 2018). Furthermore, we noticed that anxiety and depression showed higher rates in young individuals with DMDD than in psychiatric individuals (Copeland, Shanahan, Egger, Angold, & Costello, 2014). It is worthy to mention that there is limited literature concerning the executive function (EF) impairments in the DMDD group that was documented in previous studies (Mulraney et al., 2016).

The anatomical EF processes in the brain could be referred to as the prefrontal cortex (PFC) (Broche-Pérez, Jiménez, & Omar--Martínez, 2016). Hence, the impairment of EF could be gained from the cortical layers of the lateral PFC (Fuster, 2001), and injury to the frontal cortex causes executive dysfunction. Moreover, the prefrontal cortex is connected to various complex behaviors such as planning/decision-making, personality development, etc. These impairments of mental skills are origin to the executive function. As an important highlight, the impairments of neuropsychological properties in both DMDD and ADHD groups are actually similar to each other (Taşkıran, 2017), while children who shared DMDD displayed greater activation in the Superior Frontal Gyrus (SFG), which is a region implicated in the regulation of executive attention (Mikita & Stringaris, 2013).

The majority of the research has yielded evidence of various aspects of EF, for instance, inhibitory control, which supported that the individuals with ADHD have deficiencies in their motor inhibition, but it is far from the individuals with autism spectrum disorder (ASD). Conversely, individuals with ADHD and individuals with autism spectrum disorder (ASD) consistently revealed impairment in EF, but it is far from individuals with conduct disorder (without ADHD), and Tourette syndrome individuals (Pennington & Ozonoff, 1996).

To address the inhibition and working memory (WM) tasks, the literature suggested sensitivity to frontal lobe function (Welsh, Satterlee-Cartmell, & Stine, 1999). Concerning the link between visual recognition memory and EF, the evidence showed that early experiences could be continued to develop learning memory and executive functioning during pre-adolescence years in children with Institutional Rearing (Bick, Zeanah, Fox, & Nelson, 2018). Due to the lack of ability to obtain effective and selective information, the short attention span of individuals with ADHD is notable (Cho et al., 2004), while the defect in working memory in individuals with ASD has not shown a significant difference in individuals with ADHD. Also, sustained attention is maintaining attention to one particular task over a period of time (Goethals, Audenaert, Van de Wiele, & Dierckx, 2004). Thus, sustained attention impairment is a potential to end phenotype, or it could even be related to genetic risk in individuals with ADHD (Mastronardi et al., 2016).

In addition, children with ADHD and DMDD displayed a weaker self-control ability than children with ADHD without DMDD (Mulraney et al., 2016), to subscribe the self-monitoring as a way to express behavior in asocial appropriateness, it could be increased in individuals with ADHD on behavior tasks, followed by a 24-day intervention period (Moore, 2018). However, the study is research on EF ability in children's development bridges the fundamental body of many studies to illuminate an accurate relationship. For instance, Barkley (1997) found that individuals with ADHD demonstrated impairments of secondary effective execution, such as reconstitution, internalization of speech, self-regulation of effective motivation arousal, and working memory. Indeed, this model is a potential theory of self-control and ADHD, as mentioned, which could reveal the inhibition links to four executive neuropsychological conditions by appearing in these effective executions (Barkley, 1997).

Based on the limited research on DMDD and the concept of DMDD is relatively new. We hypothesized that the point if there is a significant difference in the executive functions of inhibition between the three groups of children with DMDD, with ADHD, and TD group. Furthermore, we compared differences in the executive functions in children with symptoms of DMDD with children with symptoms of ADHD and TD with respect to the working memory and sustained attention variables as well as regarding the Barclay Executive Insufficiency Scale.

The aim of this study is to shed more light on differences or impairments of EF ability in individuals with DMDD, ADHD, and TD. Hence, it provides a comprehensive overview of the central features of the executive function.

1. Method

1.1. Participants

We investigated these hypotheses in the participants were 14 Iranian children between 6–12 years old, who were randomly chosen using stratified random sampling. DMDD (N = 11, 8 males, 3 females, mean age (SD) = 7.18 (1.25) years, mean IQ (SD) = 95.27 (9.91)), ADHD (N = 1511 males, 4 females, mean age (SD) = 7.93 (1.38) years, mean IQ (SD) = 95.93 (6.93)), and TD, (N = 1512 males, 3 females, mean age (SD) = 7.86 (1.40) years, mean IQ (SD) = 96.26 (8.40)). These three groups were homogeneous in terms of socioeconomic status, gender, age, and IQ.

The subjects had to meet all of the following criteria to be eligible for enrollment into the study: IQ < 80, not reporting premature birth history or birth trauma, not having specific learning difficulties, not taking psychiatric medications or medical therapies during a test, and not having comorbid disorders other than DMDD and ADHD. None of typically developing children (TD) showed any symptoms of the psychiatric disorder according to DSM-IV criteria.

1.2. Measures

1.2.1. Clinical interview

In the current research, a semi-structured clinical interview, based on the 5-DSM criteria, has been implemented to diagnose the children who have DMDD and ADHD symptoms, as measured by a child and adolescent psychiatrist.

1.2.2. The Raven's Progressive Matrices (RPMs)

Raven's Progressive Matrices (RPMs) is a well-validated nonverbal test to estimate the intelligence cognitive functioning in children and adults, originally developed by John C. Raven (Raven, 1936). This is an untimed test but approximately takes between 15−45 min. For each task, an answer is considered correct with 1, and 0 for an incorrect response. The Iranian version was frequently used in past studies with Iranian individuals for the standardization of this test (Rajabi, 2008). This test has been implemented to match the intelligence range among groups.

1.2.3. Go/No-Go task

This task is referred to inhibitory control (in the motor cortex) as the positive and negative stimuli; requiring a response to every stimulus (Go task), requiring a response to all but the "stop" stimulus (No/go tasks) is failed (Shucard, McCabe, & Szymanski, 2008). The target (go) stimulus has been presented as a triangle shape; the non-target (no-go) stimulus was other geometric shapes in the center of a black screen for 500 milliseconds (half a second), 60 cm from the sample's eyes. The participants must press a button provided on the keypad when they see Go, and if other geometric shapes are appeared (No-go), they need to make sure they do not press the button. Whenever a target stimulus was present 70 times, from 100 efforts in total, to create an influential relationship in Go trial performance. The numbers of the commission were replies to a No-Go signal and of omission a no reply to a Go signal. It was important to make sure that the participants were able to identify the triangle shape among other shapes (Murphy et al., 1999). So, this task required subjects or shapes of stimuli presented individually in the center of a computer screen and respond as rapidly of subjects pressed a mouse button when ready to begin which were administered in a single session.

1.3. N-Back task

The N-Back task was developed by Wayne Kirchner (1958) which extensively used to assess working memory ability (each stimulus is held in short-term memory while new stimuli are presented). In this task, if the participant's response matched the visuospatial stimuli with the previous response, they press a button on a computer keyboard (key one), which appeared one at a time in the center of their computer monitor. While the non-match response would press key two; so, they showed the answer by 2 keys (2 and 1) on their computer keyboard. These stimuli presented in the center of a black screen for 500 milliseconds, followed by a 1500-millisecond black screen (Gevins & Cutillo, 1993). The task involved 30 target visuospatial stimuli and 60 non-target stimuli responses.

1.3.1. Continuous Performance Test (CPT)

The Continuous Performance Test (CPT) is a behavioral assessment developed by Rosvold, Mirsky, Sarason, Bransome, and Beck (1956) to evaluate sustained and/or selective attention. Some variables such as errors of omission, commission, omission (Conners & MHS Staff, 2004), mean hit reaction time (RT), mean hit RT standard error (Sandford, 1995), and beta (Conners & MHS Staff, 2004) could be obtained from the current test. As mentioned, the series of letters (numbers between 0 and 9 were randomly) present 210 times as the target stimulus randomly a white fixation cross in the center of a black screen for 800 milliseconds (60 cm from their eyes).

The participants have to respond whenever a "first stimuli" (in the current study randomly selected number 4) is present 30 times (20 % of trials) by pressing a key space in the keyword. However, no response (other rest numbers) stimulus appears 210 times (80 % of trials) response by not pressing it. The presentation time for each number was 800 thousandths of a second, and each item appears within one second from another. During the test, in the computer monitor (on page 44) stimulus appeared different numbers. So, participants respond by pressing a button each time a predesignated target stimulus number appears, they press a button on a computer keyboard (space key) when the number 1 stimuli appear, and not press the button when another character or number was as a target.

1.3.2. The Barkley Deficits in Executive Functioning Scale Children and Adolescents (BDEFS-CA) (Russell a Barkley, 2012)

This scale is an empirically based tool for evaluating clinically significant dimensions of child and adolescent Executive Functioning (EF) completed by parents. It is an empirical instrument to assess various dimensions of deficits of executive functions in daily life activities (such as time management, organization, and problem-solving, self-restraint, self-motivation, and self-regulation of emotions) for children and adolescents at 6–18 years old. Two parent-report forms are included: A Long Form (10−15 min) and a Short Form (3−5 min). We documented the Long Form to measure the ADHD scale. A previous study has shown that the scale has good reliability and validity for Iranian individuals.

1.4. Procedure

A number of well-known psychologists and psychiatrists implemented semi-structured interviews in Ebn'e Sina hospital to identify the children with DMDD (Educational Psychiatric Hospital of the Mashhad University of Medical Sciences) or at other psychology clinics. After a lot of follow-up work (telephone, e-mail, and weekly visits), children were selected for entry and attendance to do the tests by referral to Soroush's psychological clinic. Two psychologists in the Soroush clinic identified the children with ADHD for entry to the current study. Before implementing the tests through a short interview, parents answered questions based on their knowledge of their own children: 1) the reason for the referral to a psychiatrist, 2) main problems in a child's education, or 3) how the child's relationship with other family members is. It is useful to identify the historical background of older adolescents with ADHD disorder. One meaningful way to reduce stress and feelings of inconvenience in children is to ask questions about their interests, such as having siblings or favorite lessons in school. We used "game" instead of "test" or "evaluation" because this word is less stressful. These tests were attractive enough for our participants to ask us to repeat after finishing; meanwhile, the researcher took notes of the child's

behavior. It is worth noting that typically-developing children (TD) were selected in terms of their age, intelligence, and non-psychological disorders in different private schools in Mashhad. The procedure was the same as previous ones, but the tests were taken individually in a quiet room in their school.

1.5. Statistical analysis

Data on the measures have been analyzed through MANOVA test. In data analysis, we used the SPSS (version 23) program to analyze all calculations.

2. Results

Table 1 presents the demographic characteristics of three groups of children including age, gender, and educational level in terms of descriptive and inferential data such as frequency, percentage, mean and standard deviation. It is worth mentioning that the number of boys (70 %) was greater in both DMDD and ADHD groups than girls. Previous studies have reported a higher prevalence of both disorders in boys. Importantly, the highest frequency was related to the third grade in individuals with ADHD. In addition, the Mean age is approximately 7 years old in all three groups, and the Mean IQ in both groups of DMDD and ADHD is approximately the same, but in comparison, the typically-developing children (TD) group is larger than their peers in clinical groups.

Table 2 presents means and standard deviations of scores taken from various tasks separately for each group of children, such as Go/No-Go task (inhibition skill), N-Back task (Working memory skill), Continuous Performance Test (CPT) (Sustained attention skill), and BDEFS-CA scale.

Table 2 presents outcomes for our primary hypotheses concerning the three-study group performance in Go/No-Go, N-Back task, CPT, and BDEFS-CA scale.

With regard to the Go/No-Go task, as shown in Table 2, MANCOVA indicated significant differences ($F= 74.6$). Tukey post hoc analyses indicated a not significant difference between DMDD and ADHD, while we found significant differences between DMDD, ADHD, and TD individuals, which documented the average rate was lower in a typical group than other groups. So, in this task, the children diagnosed with ADHD had greater reaction times, more commission errors (a human error wherein an operator plays a wrong or extra action, which includes pressing a control button twice, causing the function to be performed incorrectly or twice) than DMDD and typically developing children, and also, and ADHD more omission errors (a human error wherein an administrator fails to carry out a fundamental step or activity like pressing a control button, causing a function to fail) compared to typically developing children, and DMDD. Working memory was measured by N-Back test, hence with regard to this task, as shown in Table 2 in the same picture used MANCOVA method through Tukey post hoc analyses who indicated significant differences between DMDD, ADHD, and TD individuals ($F = 1.58, P > 0.05$) which both DMDD, ADHD groups obtained less rate than typical individuals.

The children with ADHD and DMDD had equal commission errors, but typically developing children have less of it. Also, the children with ADHD more reaction times compared to typically developing children, but less than children with DMDD. The reaction times in children with ADHD were more than in TD children as well.

Also, with regard to CPT, as shown in Table 2, similarly MANCOVA was used which indicated significant differences between DMDD and ADHD individuals $F = 3.34$ ،$P < 0.05$. While through Tukey post hoc analyses were no significant difference between DMDD and ADHD groups was addressed.

Children diagnosed with DMDD had greater reaction times and omission errors than ADHD and typically developing children, and ADHD reaches more commission errors compared to typically developing children and DMDD.

Concerning BDEFS-CA, Table 2 shows that there is a significant difference between groups - time management: $F= 51.87, P < .05. \eta p2 = 0.73$; organization and problem solving: $F = 46.73, P < .001, \eta p2 = 0.71$; self-restraint: $F = 72.48, P < .05, \eta p2 = 0.79$; self-motivation: $F = 36.59, P < .05. \eta p2 = 0.66$; self-regulation of emotions: $F = 95.50, P < .05, \eta p2= .83$. Hence, there was not significant difference between the ADHD and DMDD groups.

Finally, the children diagnosed with DMDD had greater total scores than ADHD, also had more self-restraint and organization, and problem-solving, and had less time management and self-motivation compared to DMDD. The children with ADHD and DMDD had

Table 1
Sociodemographic characteristics.

	DMDD (n = 11)	ADHD (n = 15)	TD (n = 15)
Sex- male, n (%)	8 (72 %)	11 (73.3 %)	12 (80 %)
Age, Mean (SD)	7.18 (1.25)	7.93 (1.38)	7.86 (1.40)
IQ, Mean (SD)	95.27 (9.91)	95.93 (6.93)	96.26 (8.40)
Grade level			
Pre-school, n (%)	4 (36 %)	4 (26 %)	3 (20 %)
First, n (%)	3 (27 %)	1 (6 %)	3(20 %)
Second, n (%)	3 (27 %)	3 (20 %)	5(34 %)
Third, n (%)	–	6 (40 %)	1(6 %)
Fourth, n (%)	1 (9 %)	1 (6 %)	3 (20 %)

Note: DMDD = Disruptive Mood Dysregulation Disorder; ADHD = Attention-Deficit Hyperactivity Disorder; TD = Typically Development; IQ = Intelligence quotient.

Table 2
Comparison of groups according to the measures.

7	DMDD (n = 11) M(SD)	ADHD (n = 15) M(SD)	TD (n = 15) M(SD)	F	Effect size
Go/No-Go task					
Commission error	39.72 (7.90)	35.93 (6.02)	28.49 (3.50)	12.73**	0.4
Omission error	40.63 (6.94)	41.33 (10.92)	30.80 (6.50)	6.90**	0.27
Reaction times mean	362.96 (53.34)	353.63(58.23)	298.57(52.12)	5.52**	0.23
***N*-Back task**					
Correct answer	48.90 (8.22)	48.53 (9.07)	61.3(14.85)	6.38**	0.25
Reaction times mean	748.09 (211.3)	775.46(136.77)	690.46(130.85)	1.08	0.05
Continuous Performance Test (CPT)					
Commission error	3.46 (1.63)	2.33 (1.39)	1.13 (0.51)	12.53**	0.4
Omission error	3.45 (2.33)	4.60 (2.41)	2.20 (1.01)	5.36**	0.22
Reaction times mean	680.67 (89.2)	679.04 (70.5)	628.56 (68.5)	2.13	0.11
BDEFS-CA					
Time management	36.90(5.64)	4.60 (4.10)	17.53 (2.85)	51.87**	0.73
Organization	37.54 (4.94)	36.80 (4.81)	15.93 (1.38)	46.73**	0.71
Restraint	38.09 (2.66)	38.53 (4.58)	17.13 (2.99)	72.48**	0.79
Motivation	35.81 (4.37)	36.93 (4.38)	19.26 (4.84)	36.59**	0.66
Emotion regulation	53.45(4.15)	45.00 (4.89)	22.13 (3.29)	95.50**	0.83

Note: DMDD = Disruptive Mood Dysregulation Disorder; ADHD = Attention-Deficit Hyperactivity Disorder; TD = Typically Development; IQ = Intelligence quotient; BDEFS-CA: The Barkley Deficits in Executive Functioning Scale, Children and Adolescents.
** $P < 0.05$.

equal self-regulation of emotions, and in all subscales had greater scores compared to typically developing children. Indeed, a higher score indicates lower performance on it.

3. Discussion

The present study confirms earlier findings that individuals with ADHD and DMDD display poor inhibition ability compared to their peer TD individuals (Barkley, 1997; Copeland et al., 2014). Further, in accordance with inhibition behavior in children with DMDD, studies documented that child with ADHD often have more difficulties in behavioral inhibition (Stevens, Quittner, Zuckerman, & Moore, 2002). Also, results revealed that the DMDD individuals particularly presented behavioral inhibition and emotional disinhibition. Poor capacity to own control leads to self-regulation and impulsive behavior. Overall, inhibition can lead to the inability to control violent behavior, and it predicted anger and irritability in children with DMDD. It causes harm to them and others (Tufan et al., 2016). A disability on behavioral inhibition in DMDD seems to occur in the left frontal activity (Rybak, Crayton, Young, Herba, & Konopka, 2006), so probably inability in their behavior or lack of attention maintenance could lead to reducing memory performance.

One interesting finding in the literature is that children with ADHD and DMDD disorders are predicted to have fewer functions of working memory than typical ones in terms of the n-back task analysis. Several studies considered that impairment of WM accounts for a fundamental cognitive deficiency in ADHD individuals (Klingberg, 2010; Klingberg, Forssberg, & Westerberg, 2002; Wang et al., 2018). In addition, the WM difficulties in both ADHD and DMDD individuals in numerous previous studies were documented (Campbell & Sharma, 2017; Taskiran, Mutluer, & Necef, 2017). Specifically, this study shows that the low working memory performance in DMDD due to the interference with unrelated information with previous literature has been limited (Campbell & Sharma, 2017; Taskiran et al., 2017). To identify the common and distinct neural signatures, both DMDD and ADHD groups were compared with their healthy peers (Pagliaccio et al., 2017), and children with DMDD were not as poor as the children with ADHD (Taşkıran, 2017). As expected, the evidence suggests that the sustained attention in our groups performed clear differences in the CPT task. The sustained attention capacity helps the children to maintain the attention, and focus on a particular stimulus. The omission errors might be related to attention problems, and also commission errors might be related to inadequate control, or impulsivity (Taşkıran, 2017). Indeed, the allocation of attention resources is an important construct for understanding irritable mood and temper outbursts in children. Individual differences in attention control abilities may impact the efficacy of emotion regulation processing (McRae et al., 2010).

Therefore, the reason for irritable behavior in children with DMDD and ADHD conditions may refer to their action without considering the consequences, response without thought to the objective stimuli, and lack of attention, and decentralization that often lead to missing the stimuli target during the test. However, the key finding from the present study is that the subjects in all five subscales of Barclay scale demonstrated a high difference in self-motivation, self-organizing, time management, and self-control between the patient groups and the healthy controls. As we concluded through the implementation of the emotional regulation scale, there has been more differences in both ADHD and DMDD groups.

Thus, our study also extends beyond previous research to limited ability to regulate emotion in this clinical condition. Additionally, the severe temper outbursts, which are also reflections of poor regulation of negative affective responses are considered to be a hallmark of DMDD symptom, it is probably reflecting a more extreme form of irritability (Leibenluft, 2011; Leibenluft, Charney, Towbin, Bhangoo, & Pine, 2003; Stringaris, Cohen, Pine, & Leibenluft, 2009). Of course, such a finding is only indirect. The person with emotional maintenance problems usually performed a poor capacity in the attentional maintenance, planning, or has impairment of direction in his or her own target behavior.

4. Conclusion

In conclusion of our results, we believe in adding to the literature of executive function. Notably, the EF in DMDD performs much poorer capacity in DMDD than in TD individuals. Although, these two groups displayed the same profiles in EF ability. On the other side, DMDD groups are not lucky in self-regulation of emotions camper to ADHD group. As summarized, the impulsive behavior, cognitive, and emotional problems in all these groups have the strong correlation and referred to inability of inhibition, sustainable attention, working memory, and self-regulation of emotional skills documented the evidence in the current study.

5. Imitations

One of the most central limitations of the present study is the small sample size of the DMDD group. Therefore, we encourage future studies to extend with a larger sample to increase the validity, and generalization seems to be required. The other important limitations of the study are selecting children within convenient and random sampling. One interesting recommendation for future research therefore would be to explore with a wider sample and to attain more cooperation of various clinical centers, and also, pay attention to executive function in DMDD is essential, due to little previous literature in the current area. Another important recommendation that has to be considered in future research is investigate outcomes in other various factors, to have a better possibility to illuminate the interconnection factors like emotional problems.

References

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychological Bulletin, 121*(1), 65–94. https://doi.org/10.1037/0033-2909.121.1.65.

Barkley, R. A. (2012). *Barkley Deficits in Executive Functioning Scale–Children and Adolescents (BDEFS-CA)*. Guilford Press.

Bick, J., Zeanah, C. H., Fox, N. A., & Nelson, C. A. (2018). Memory and executive functioning in 12-year-old children with a history of institutional rearing. *Child Development, 89*(2), 495–508. https://doi.org/10.1111/cdev.12952, 495–508.

Broche-Pérez, Y., Jiménez, L. F. H., & Omar-Martínez, E. (2016). Neural substrates of decision-making. *Neurología (English Edition), 31*(5), 319–325. https://doi.org/10.1016/j.nrleng.2015.03.009.

Campbell, L. R., & Sharma, N. (2017). 4.19 Access to care for transgender youth. *Journal of the American Academy of Child & Adolescent Psychiatry, 56*(10), S234–S235. https://doi.org/10.1016/j.jaac.2017.09.235.

Cho, B. H., Kim, S., Shin, D. I., Lee, J. H., Min Lee, S., Young Kim, I., & Kim, S. I. (2004). Neurofeedback training with virtual reality for inattention and impulsiveness. *Cyberpsychology & Behavior, 7*(5), 519–526. https://doi.org/10.1089/cpb.2004.7.519.

Conners, C. K., & Staff, M. (2004). Conners' continuous performance test II (CPT II V. 5). North Tonawanda. San Antonio, TX. Chicago.

Copeland, W. E., Shanahan, L., Egger, H., Angold, A., & Costello, E. J. (2014). Adult diagnostic and functional outcomes of DSM-5 disruptive mood dysregulation disorder. *American Journal of Psychiatry, 171*(6), 668–674. https://doi.org/10.1176/appi.ajp.2014.13091213.

Diagnostic and statistical manual of mental disorders (DSM-5®). (2013). American Psychiatric Pub.

Fuster, J. M. (2001). The prefrontal cortex—An update: Time is of the essence. *Neuron, 30*(2), 319–333. https://doi.org/10.1016/S0896-6273(01)00285-9.

Gevins, A., & Cutillo, B. (1993). Spatiotemporal dynamics of component processes in human working memory. *Electroencephalography and Clinical Neurophysiology, 87*(3), 128–143. https://doi.org/10.1016/0013-4694(93)90119-G.

Goethals, I., Audenaert, K., Van de Wiele, C., & Dierckx, R. (2004). The prefrontal cortex: Insights from functional neuroimaging using cognitive activation tasks. *European Journal of Nuclear Medicine and Molecular Imaging, 31*(3), 408–416.

Kirchner, W. K. (1958). Age differences in short-term retention of rapidly changing information. *Journal of Experimental Psychology, 55*(4), 352. https://doi.org/10.1037/h0043688.

Klingberg, T. (2010). Training and plasticity of working memory. *Trends in Cognitive Sciences, 14*(7), 317–324. https://doi.org/10.1016/j.tics.2010.05.002.

Klingberg, T., Forssberg, H., & Westerberg, H. (2002). Training of working memory in children with ADHD. *Journal of Clinical and Experimental Neuropsychology, 24*(6), 781–791. https://doi.org/10.1076/jcen.24.6.781.8395.

Leibenluft, E. (2011). Severe mood dysregulation, irritability, and the diagnostic boundaries of bipolar disorder in youths. *The American Journal of Psychiatry, 168*, 129–142.

Leibenluft, E., Charney, D. S., Towbin, K. E., Bhangoo, R. K., & Pine, D. S. (2003). Defining clinical phenotypes of juvenile mania. *American Journal of Psychiatry, 160*(3), 430–437. https://doi.org/10.1176/appi.ajp.160.3.430.

Mastronardi, C. A., Pillai, E., Pineda, D. A., Martinez, A. F., Lopera, F., Velez, J. I., … Arcos-Burgos, M. (2016). Linkage and association analysis of ADHD endophenotypes in extended and multigenerational pedigrees from a genetic isolate. *Molecular Psychiatry, 21*(10), 1434–1440. https://doi.org/10.1038/mp.2015.172.

McRae, K., Hughes, B., Chopra, S., Gabrieli, J. D., Gross, J. J., & Ochsner, K. N. (2010). The neural bases of distraction and reappraisal. *Journal of Cognitive Neuroscience, 22*(2), 248–262. https://doi.org/10.1162/jocn.2009.21243.

Mikita, N., & Stringaris, A. (2013). Mood dysregulation. *European Child & Adolescent Psychiatry, 22*(Suppl. 1), S11–S16.

Moore, S. (2018). *The effects of self-monitoring on on-task behavior in ADHD students*. http://hdl.handle.net/11603/11023.

Mulraney, M., Schilpzand, E. J., Hazell, P., Nicholson, J. M., Anderson, V., Efron, D., … Sciberras, E. (2016). Comorbidity and correlates of disruptive mood dysregulation disorder in 6–8-year-old children with ADHD. *European Child & Adolescent Psychiatry, 25*(3), 321–330. https://doi.org/10.1007/s00787-015-0738-9.

Murphy, F. C., Sahakian, B. J., Rubinsztein, J. S., Michael, A., Rogers, R. D., Robbins, T. W., & Paykel, E. S. (1999). Emotional bias and inhibitory control processes in mania and depression. *Psychological Medicine, 29*(6), 1307–1321. https://doi.org/10.1017/S0033291799001233.

Pagliaccio, D., Wiggins, J. L., Adleman, N. E., Curhan, A., Zhang, S., Towbin, K. E., & Leibenluft, E. (2017). Behavioral and neural sustained attention deficits in disruptive mood dysregulation disorder and attention-deficit/hyperactivity disorder. *Journal of the American Academy of Child & Adolescent Psychiatry, 56*(5), 426–435. https://doi.org/10.1016/j.jaac.2017.02.008.

Pennington, B. F., & Ozonoff, S. (1996). Executive functions and developmental psychopathology. *Journal of Child Psychology and Psychiatry, 37*(1), 51–87. https://doi.org/10.1111/j.1469-7610.1996.tb01380.x.

Rajabi, G. R. (2008). Standardization of the Raven's Progressive Matrices test in school children in Ahwaz. *Contemporary Psychology, 3*(1), 23–32.

Raven, J. C. (1936). *Mental tests used in genetic studies: The performance of related individuals on tests mainly educative and mainly reproductive*. MSc Thesis. London: University of London.

Rosvold, H. E., Mirsky, A. F., Sarason, I., Bransome, E. D., Jr., & Beck, L. H. (1956). A continuous performance test of brain damage. *Journal of Consulting Psychology, 20*(5), 343. https://doi.org/10.1037/h0043220.

Rybak, M., Crayton, J. W., Young, I. J., Herba, E., & Konopka, L. M. (2006). Frontal alpha power asymmetry in aggressive children and adolescents with mood and disruptive behavior disorders. *Clinical EEG and Neuroscience, 37*(1), 16–24. https://doi.org/10.1177/155005940603700105.

Sandford, J. A., & Turner, A. (1995). *Manual for the integrated visual and auditory continuous performance test.* Richmond, VA: Braintrain.

Shucard, J. L., McCabe, D. C., & Szymanski, H. (2008). An event-related potential study of attention deficits in posttraumatic stress disorder during auditory and visual Go/NoGo continuous performance tasks. *Biological Psychology, 79*(2), 223–233.

Stevens, J., Quittner, A. L., Zuckerman, J. B., & Moore, S. (2002). Behavioral inhibition, self-regulation of motivation, and working memory in children with attention deficit hyperactivity disorder. *Developmental Neuropsychology, 21*(2), 117–139. https://doi.org/10.1207/S15326942DN2102_1.

Stringaris, A., Cohen, P., Pine, D. S., & Leibenluft, E. (2009). Adult outcomes of youth irritability: A 20-year prospective community-based study. *American Journal of Psychiatry, 166*(9), 1048–1054. https://doi.org/10.1176/appi.ajp.2009.08121849.

Taskiran, S., Mutluer, T., & Necef, I. (2017). 4.16 Neuropsychological profile differences between children with disruptive mood dysregulation disorder (DMDD) and attention-deficit/hyperactivity disorder (ADHD): A preliminary study. *Journal of the American Academy of Child & Adolescent Psychiatry, 56*(10), 233–S234. https://doi.org/10.1016/j.jaac.2017.09.232.

Taşkıran, S. (2017). How does emotional dysregulation translate into psychopathology? *Klinik Psikofarmakoloji Bulteni, 27*, 293–295. Retrieved from https://search.proquest.com/docview/1935200421?accountid=15292.

Tourian, L., LeBoeuf, A., Breton, J. J., Cohen, D., Gignac, M., Labelle, R., & Renaud, J. (2015). Treatment options for the cardinal symptoms of disruptive mood dysregulation disorder. *Journal of the Canadian Academy of Child and Adolescent Psychiatry = Journal de l'Academie canadienne de psychiatrie de l'enfant et de l'adolescent, 24*(1), 41–54.

Tufan, E., Topal, Z., Demir, N., Taskiran, S., Savci, U., Cansiz, M. A., & Semerci, B. (2016). Sociodemographic and clinical features of disruptive mood dysregulation disorder: A chart review. *Journal of Child and Adolescent Psychopharmacology, 26*(2), 94–100. https://doi.org/10.1089/cap.2015.0004.

Wang, C., Yang, B., Fang, D., Zeng, H., Chen, X., Peng, G., & Liang, G. (2018). The impact of SNAP25 on brain functional connectivity density and working memory in ADHD. *Biological Psychology, 138*, 35–40. https://doi.org/10.1016/j.biopsycho.2018.08.005.

Welsh, M. C., Satterlee-Cartmell, T., & Stine, M. (1999). Towers of Hanoi and London: Contribution of working memory and inhibition to performance. *Brain and Cognition, 41*(2), 231–242. https://doi.org/10.1006/brcg.1999.1123.

Wiggins, J. L., Brotman, M. A., Adleman, N. E., Kim, P., Wambach, C. G., Reynolds, R. C., & Leibenluft, E. (2017). Neural markers in pediatric bipolar disorder and familial risk for bipolar disorder. *Journal of the American Academy of Child & Adolescent Psychiatry, 56*(1), 67–78. https://doi.org/10.1016/j.jaac.2016.10.009.