Author Accepted Manuscript version of the paper by Andersen, Ann Christin et al in Child Neuropsychology, (2023), DOI 10.1080/09297049.2023.2174506

Executive Function Measured by BRIEF in Adolescents Diagnosed and Treated for ADHD: Problem Profiles and Agreement Between Informants

Ann Christin Andersen, MD[1], Anne Mari Sund, MD, PhD[1,2], Per Hove Thomsen, MD, PhD[1,3], Stian Lydersen, PhD[1], Anne-Lise Juul Haugan, MSc[1], Torunn Stene Nøvik, MD, PhD[1,2]

Author affiliations:

[1]Regional Centre for Child and Youth Mental Health and Child Welfare (RKBU), Department of Mental Health, Faculty of Medicine and Health Sciences, NTNU- Norwegian University of Science and Technology, Trondheim, Norway

[2]Department of Child and Adolescent Psychiatry, St. Olav University Hospital, Trondheim, Norway

[3]Department of Child and Adolescent Psychiatry, Aarhus University Hospital, Skejby, Denmark.

Running Title: Executive Function Deficits in Adolescent ADHD

Correspondence:

Ann Christin Andersen,

RKBU Mid-Norway NTNU, P.O. Box 8905 MTFS, 7491 Trondheim, Norway

E-mail: ann.c.andersen@ntnu.no

Orcid-id: https://orcid.org/0000-0002-8402-5605

Twitter: @AnnChrAndersen

LinkedIn: linkedin.com/in/ann-christin-andersen-40b00a6b/

Abstract

Executive functional deficits (EFDs) play an important role in functional impairment in adolescents with attention deficit/hyperactivity disorder (ADHD). More knowledge of executive function (EF) profiles and informant discrepancies will guide clinicians and provide tailored treatment advice. The objectives of this study were to use teacher, parent, and self-reported EF ratings to describe (a) problem profiles and (b) the correlation and agreement between informants. This study included 100 adolescents aged 14-18 years with ADHD still experiencing clinically impairing symptoms despite standard treatment including medication. EFs were measured using *the Behavior Rating Inventory of Executive Functioning* (BRIEF). Agreement between informants was quantified using Pearson correlation and informant discrepancies were analysed using paired samples t-test. Overall, the results indicated considerable EFDs in the study population. Correlation and agreement varied between the informants. Agreement was highest between adolescents and their parents, especially for female participants, and lowest between male participants and their teachers. Teachers reported the highest level of EFDs, whereas adolescents generally self-reported EFDs at a lower level than both parents and teachers. Identifying and tailoring treatment for EFDs might improve future prognosis for adolescents with ADHD, however, self-awareness of these difficulties is a challenge that needs to be considered when planning interventions.

Keywords ADHD, Adolescents, Executive Function

Introduction

Attention deficit/hyperactivity disorder (ADHD) is a neurodevelopmental disorder characterised by impaired symptoms of inattention, hyperactivity, and impulsivity (American Psychiatric Association, 2013). Although often diagnosed in childhood, there are high persistence rates in adolescence and adulthood (Barkley et al., 2002; Sibley et al., 2017). Adolescents with ADHD often struggle in many areas of their lives, psychiatric comorbidity is common, and there is a high risk of adverse outcomes (Arnold et al., 2020; Franke et al., 2018; Jensen & Steinhausen, 2015). There is increased awareness of the complexity of developmental trajectories for these patients, and different phenotypes might warrant different treatment approaches (Coxe et al., 2021). Current treatment recommendations include psychoeducational and supportive measures and medication, but these are often insufficient to normalise function (Posner et al., 2020). A broad range of psychosocial treatments has been developed in recent years, but the overall effect of non-pharmacological treatment for ADHD is inconclusive (Chan et al., 2016).

Executive functions (EFs) are collectively described as processes involved in planning, directing, and managing cognitive, emotional, and behavioural functions, especially during active problem solving (Gioia, Isquith, Retzlaff, et al., 2002). Although not part of the diagnostic criteria and not disorder-specific, there is a growing consensus that executive functional deficits (EFDs) are an important part of ADHD (Willcutt et al., 2005). EFDs have been shown to cause a high degree of impairment and are associated with poor academic and occupational outcomes (Biederman et al., 2004; Dvorsky & Langberg, 2019). EFs also play an important role in self-appraisal and the ability to regulate emotions (Lantrip et al., 2016). Previous studies have indicated that EFDs persist into adolescence and young adulthood (Fossum et al., 2021; Zelazo & Carlson, 2012). With increasing age, there is an increased need for more complex metacognitive aspects of EF in both academic and social settings,

with a higher risk of functional impairment when EFDs are present (Dvorsky & Langberg, 2019; Jacobson et al., 2011). Several studies have highlighted the important relationship between EFDs and functional impairment in adults (Biederman et al., 2006; Halleland et al., 2019). These findings underline the importance of identifying these difficulties early in life and the need to develop better interventions targeting EFDs in children and adolescents.

Previous studies have shown that the combined use of performance-based tests and rating scales provide complementary information useful for the assessment of children and adolescents with neurodevelopmental disorders (Halvorsen et al., 2019; Krieger & Amador-Campos, 2018). Studies have also shown that the behavioural ratings of EFs correlate better with functional outcomes and have higher ecological validity than formal neuropsychological tests (Barkley & Fischer, 2011; Toplak et al., 2008). However, evidence suggests considerable differences between informants when rating executive functions in children and adolescents (Mares et al., 2007; Soriano-Ferrer et al., 2014). EFs are dynamic, and observed deficiencies may vary across settings depending on both contextual and individual factors (De Los Reyes & Kazdin, 2005). Self-ratings of EFs might also differ from observer ratings owing to a positive illusory bias in adolescents with ADHD, as they tend to overestimate their own abilities (Chan & Martinussen, 2015; Steward et al., 2017).

Behavioural EF measures are frequently obtained as part of the diagnostic assessment in child and adolescent psychiatry (CAP). Informant discrepancies are weighed and interpreted differently, and might impact diagnostic assessment, classification, and treatment strategies (De Los Reyes & Kazdin, 2005). The reporting of EFDs in various settings will provide important information about functional impairment; however, few studies have compared the EFs reported by multiple informants in adolescents with ADHD. Self-reported measures of ADHD symptoms and impairments in general have shown limited agreement with the observed ratings (Du Rietz et al., 2016). However, findings on self-reported

behavioural ratings of EF have shown a moderate correlation with parent ratings, although a lower correlation with teacher ratings (Guy et al., 2004; Walker & D'Amato, 2006). More knowledge would improve the understanding of clinical profiles and informant discrepancies and guide clinicians towards more tailored treatment advice.

Thus, the primary objectives of the present study were to use teacher, parent, and self-reported data on behavioural EFs in a sample of adolescents diagnosed with ADHD who still experience clinically impairing symptoms after standard treatment to (a) describe problem profiles of executive functioning for this population and (b) evaluate the correlation and agreement between informants.

Materials and Methods

Participants and Procedure

This study included 100 adolescents recruited for a clinical trial of group cognitive behavioural therapy (CBT) for adolescents diagnosed with ADHD. Baseline data obtained prior to randomisation were used in the present study. Detailed accounts of the study protocol have been published previously (Haugan et al., 2022; Nøvik et al., 2020). We conducted this study at two CAP outpatient clinics at St. Olav's University Hospital in mid-Norway. This study was approved by the Regional Committee for Medical and Health Research Ethics in Southeast Norway (2015/2115). We provided oral and written information about the study prior to inclusion and obtained written informed consent from the participants or their parents if they were under the age of 16 years. The data were collected between February 2017 and September 2019.

Sample characteristics are presented in Table 1. All participants had been previously diagnosed with ADHD according to the International Statistical Classification of Diseases and Related Health Problems, 10th revision (ICD-10) (World Health Organization, 1992). The

initial diagnosis was made after a comprehensive investigation at the CAP clinic following the national guidelines for the assessment and treatment of ADHD (Helsedirektoratet, 2016). A current diagnosis of ADHD and comorbidity was confirmed at inclusion using a semi-structured diagnostic interview *Kiddie-SADS-PL, Schedule for Affective Disorders and Schizophrenia for School Aged Children -Present and Lifetime version* (KSADS-PL) (Kaufman et al., 1997). Patients with a symptom score below the threshold for ADHD according to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) criteria (American Psychiatric Association, 2013) when they were both medicated and still had impaired ADHD symptoms were diagnostically classified as having subthreshold ADHD.

Prior to inclusion in the study, all participants received standard treatment at the CAP clinic. Most participants received a short psychoeducational intervention either alone or together with their parents. Collaborative meetings were held between the CAP clinician, parents, and schoolteachers, with information about the diagnosis and advice about supportive measures related to school and homework. Parents and teachers were offered a standardised full-day course on ADHD. Children and adolescents still experiencing ADHD symptoms were offered pharmacological treatment in line with current recommendations (Helsedirektoratet, 2016). Medication was titrated and evaluated during a trial period, and if needed, a second or third medication option was attempted. Long-acting methylphenidate was normally the first drug of choice, followed by atomoxetine, amphetamines, and/or guanfacine.

The inclusion criteria were a previous full diagnosis of ADHD according to ICD-10 criteria, a current diagnosis of ADHD or subthreshold ADHD according to DSM-5 criteria, and evidence of clinically impairing symptoms (Clinical Global Impression Scale for Severity (CGI-S) score ≥3). Participants were required to be on stable ADHD-medication

(two months or longer) before inclusion. However, nine patients who had tried medication but stopped because of minimal effect or intolerable side effects were also included. The exclusion criteria were severe depression, suicidal behaviour, psychosis, intellectual disability (IQ<70), ongoing substance use, severe behavioural problems or conduct disorder, moderate to severe pervasive developmental disorder, or bipolar disorder without stable medication. A few patients undergoing psychotherapeutic interventions or previously having received CBT interventions targeting the core symptoms of ADHD were also excluded.

Table 1. Clinical Characteristics

Characteristics	
Mean age, years (SD)	15.8 (1.3)
Female Gender, n (%)	57 (57)
Full scale IQ, n (mean [SD])	86 (93.9 [12.9])
ADHD Rating Scale (ADHD-RS-V) Total Score, n (mean [SD])	
Parent-Reported	97 (24.96 [8.85])
Self-Reported	91 (21.52 [9.90])
Children's Global Assessment Scale (C-GAS), n (mean [SD])	100 (62.15 [6.87])
Clinical Global Impression Scale for Severity (CGI-S), n (mean [SD])	100 (3.94 [0.60])
ADHD presentation, n (%)	
ADHD Predominantly combined subtype	31 (31)
ADHD Predominantly inattentive subtype	35 (35)
Subthreshold ADHD	34 (34)
Medication, n (%)	
ADHD medication [a]	91 (91)
Other psychopharmacological treatment [b]	7 (7)
Psychiatric comorbidities [c], n (%)	53 (53)
Anxiety Disorders	37 (37)
Depressive Disorders/Dysthymic Disorder	11 (11)
ODD/Disruptive Behaviour Disorder NOS	11 (11)
Tic Disorders or Tourette's Disorder	9 (9)
Obsessive Compulsive Disorder	3 (3)
Autism Spectre Disorder (mild symptoms)	4 (4)
Posttraumatic Stress Disorder	1 (1)
Learning Disorders, Reading Disorders or mixed, n (%)	18 (18)

Note Full scale IQ= Wechsler Intelligence Scale for Children or Adults (WISC-IV, WAIS-IV), SD=standard deviation, ADHD=attention deficit/hyperactivity disorder

[a]ADHD medication includes methylphenidate, lisdexamphetamine, atomoxetine, and guanfacine [b]Other psychopharmacological treatment includes neuroleptic medication; risperidone, quetiapine; anti-epileptic medication: valproate, lamotrigine.

[c]Psychiatric comorbidities are based on Kiddie-SADS-PL interview with the adolescents and converted to DSM-5 diagnoses. ODD Oppositional Defiant Disorder

Measures

Executive Function:

EFs were measured using parent, teacher, and self-report forms of the *Behavior Rating Inventory of Executive Functioning* (BRIEF) (Gioia et al., 2000a). The BRIEF package contains several rating scales developed to capture the cognitive, emotional, and behavioural manifestations of executive dysfunction across different ages and informants. For the adolescent population, the relevant versions are the BRIEF self-report for ages 11-18 years (Guy et al., 2004), and the original BRIEF for ages 5-18 years with separate teacher and parent forms (Gioia et al., 2000a). The BRIEF parent and teacher form consists of 86 statements regarding different behaviours in the last six months, answered on a 3-point scale: *never*, *sometimes,* or *often.* The BRIEF self-report contains 80 statements regarding own behaviour for the last six months, rated in the same manner.

Each version of the BRIEF summarises eight empirically derived scales within two main indices and provides an overall score. The *Behavior Regulation Index* (BRI) represents the ability to shift cognitive sets and modulate emotions and behaviour. BRI summarize the *Inhibit*, *Shift*, and *Emotional Control* scales. The *Metacognition Index* (MI) represents the ability to actively solve problems- and manage different tasks. In the parent and teacher forms, MI summarises the *Initiate*, *Working Memory*, *Plan-Organize*, *Organization of Materials,* and *Monitor* scales. In the self-report version, MI includes the *Task-Completion* scale, but not the *Initiate* scale. The *Global Executive Function* (GEC) is a summary score that includes all eight clinical scales. All BRIEF-versions are found to have strong internal consistency (Gioia, Isquith, Retzlaff, et al., 2002). We performed a reliability analysis for all items in the different versions of the BRIEF used in our study. Cronbach's alpha showed good to excellent reliability with $\alpha = .88$ to .92, in line with the original American version

(Cronbach's α= .80 to .98). Previous evidence supports the instrument's reliability and validity for measuring EF (Gioia, Isquith, Retzlaff, et al., 2002). The BRIEF differentiates well between the clinical population and control groups, and more specifically, between children with and without ADHD (Gioia et al., 2000b; Sørensen & Hysing, 2014). The Norwegian version of the BRIEF teacher and parent forms have shown good psychometric properties and are considered satisfactory for clinical use in Norway with American norms (Køhn & Halvorsen, 2020; Sørensen & Hysing, 2014). The BRIEF provides raw scores that are transformed into age- and sex-adjusted T-scores. A T-score of ≥ 65 is considered clinically elevated, but sub-threshold T-scores (60-65) should also be considered as these might indicate clinical impairment. Clinical studies have shown that children with ADHD are more likely to show significantly more problems across all scales and indices on the BRIEF than non-ADHD controls (Gioia et al., 2000b; Jacobson et al., 2020). Different subtypes of ADHD can also be identified by differing profiles on the BRIEF (Gioia et al., 2000b; Jacobson et al., 2020). Higher problem scores on the BRI and underlying scales were more typical in the ADHD-combined subtype than in the ADHD-predominantly inattentive subtype.

ADHD-symptoms:

The core symptoms of ADHD were assessed using parent- and self-rated versions of the ADHD Rating Scale-IV for children and adolescents (ADHD-RS IV) (DuPaul et al., 2016). Symptoms were rated on a 4-point Likert scale, with higher scores indicating more symptoms. The severity of the adolescents ADHD-symptoms was rated on a scale from 1, *normal/not at all ill*, to 7, *among the most extremely ill patients*, by an experienced clinician using the CGI-S (Guy, 1976).

Functional Impairment:

Global psychosocial functioning was rated on a Likert-Scale from 1-100, with higher scores indicating higher function, by an experienced clinician using *The Children's Global Assessment Scale* (C-GAS) (Shaffer et al., 1983).

Statistical Analysis

We quantified the agreement between informants using Pearson correlations. The correlation coefficients were categorised as small (r=.10–.29), medium (r=.30–.49), or large (r.50–1.0) following Cohen's guidelines (Cohen, 1992). The differences (informant discrepancy) between T-scores for different informants were analysed using paired sample t-tests and the corresponding 95% confidence intervals. Missing data were handled using available case analyses. All tests were two-tailed with a significance level of .05, and the analyses were conducted using SPSS 28.

Results

The clinical characteristics of the participants are presented in Table 1. There were 100 participants in the study, with a mean age of 15.8 (SD 1.3) years. The BRIEF T-scores on the teacher, parent, and self-reported scales and indices are presented in Table 2 and illustrated in Figure 1. Participants generally self-reported EFDs at a lower level than their parents and teachers did. There was a pattern of sex differences throughout the self-reports, with female participants reporting more difficulties in self-reports than male participants. This contrasted with parent and teacher reports, where male participants are reported having more EFDs than female participants. The mean T-scores on teachers' ratings were clinically elevated (≥ 65) on all indices and scales except *Inhibit*. Parents' mean T-scores were clinically elevated for the MI and GEC but subthreshold for the BRI. Parents reported most difficulties on the *Working Memory* and *Plan-Organize* scales. Self-reported mean T-scores were clinically elevated only

on the *Working Memory* and *Task Completion* scales, but subthreshold on the *Plan-Organize* scale. GEC scores were in the clinical range for all reports except male self-reports, where the level was subthreshold.

Table 2. BRIEF T-scores, scales and indexes by informants and gender.

BRIEF,	**Total (n=100)**		**Female (n=57)**		**Male (n=43)**	
scales and indexes	**n**	**Mean (SD)**	n	**Mean (SD)**	n	**Mean (SD)**
Inhibit						
Self-report	100	59.13 (14.00)	57	62.32 (14.37)	43	54.91 (12.44)
Parents	100	61.03 (13.76)	57	59.26 (11.61)	43	63.37 (16.02)
Teachers	71	63.80 (16.72)	42	64.71 (17.61)	29	62.48 (15.54)
Shift						
Self-report	100	58.52 (13.06)	57	60.88 (12.04)	43	55.40 (13.82)
Parents	100	62.99 (11.46)	57	60.60 (10.21)	43	66.16*(12.34)
Teachers	69	74.59*(21.34)	41	75.54*(21.42)	28	73.21*(21.54)
Emotional Control						
Self-reports	100	57.06 (13.47)	57	59.89 (14.05)	43	53.30 (11.80)
Parents	100	61.98 (11.65)	57	63.68 (11.30)	43	59.72 (11.87)
Teacher	70	67.21*(19.67)	41	72.37*(20.92)	29	59.93 (15.30)
Initiate						
Parents	100	63.73 (10.77)	57	62.51 (10.72)	43	65.35*(10.74)
Teachers	71	74.65* (14.70)	42	73.74*(14.89)	29	75.97*(14.58)
Task Completion						
Self-reports	100	66.76*(12.43)	57	69.16*(11.16)	43	63.58 (13.41)
Working Memory						
Self-reports	100	66.28*(12.06)	57	69.47*(10.67)	43	62.05 (12.62)
Parents	100	72.66*(10.35)	57	72.68*(10.51)	43	72.63*(10.25)
Teachers	70	80.21*(15.70)	41	79.46*(16.01)	29	81.28*(15.46)
Plan-Organize						
Self-reports	100	60.98 (12.29)	57	63.51 (11.70)	43	57.63 (12.39)
Parents	100	69.60*(10.33)	57	71.25*(10.64)	43	67.42*(9.61)
Teachers	69	76.74*(15.16)	41	75.46*(17.08)	28	78.61*(11.86)

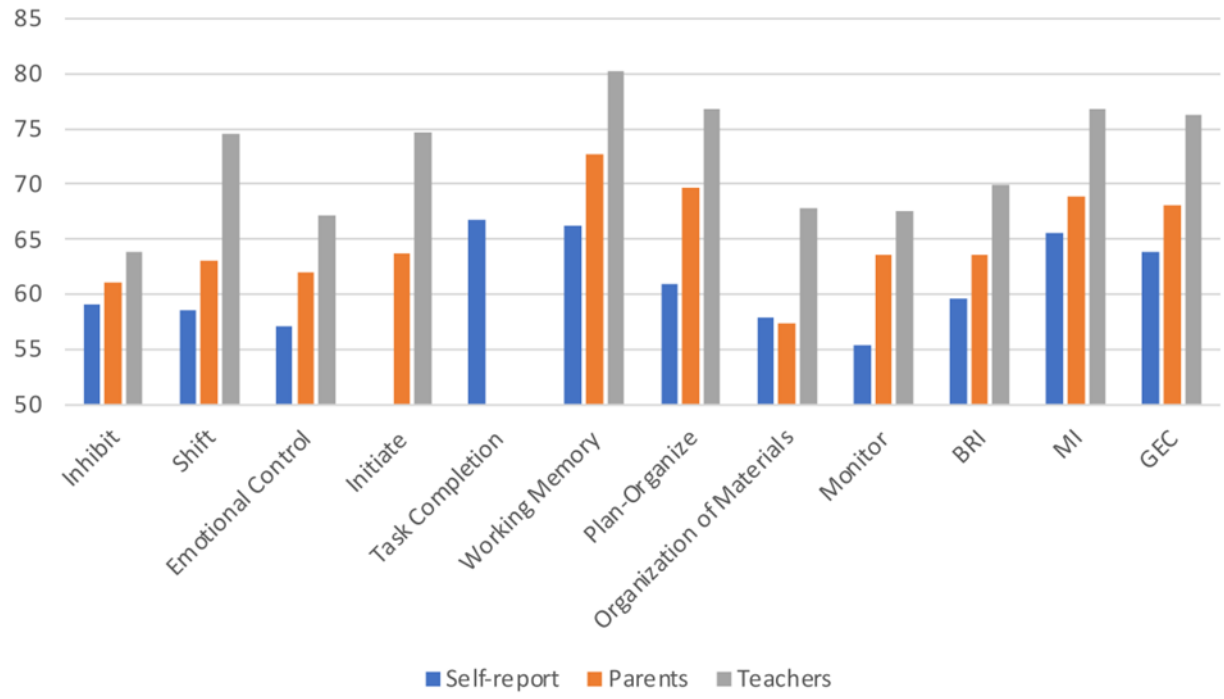
Organization of Materials						
Self-reports	100	57.95 (12.32)	57	60.14 (12.09)	43	55.05 (12.15)
Parents	100	57.37 (10.39)	57	57.04 (10.87)	43	57.81 (9.83)
Teachers	69	67.80*(21.44)	41	60.93 (15.55)	28	77.86*(24.95)
Monitor						
Self-reports	100	55.34 (12.21)	57	57.40 (12.23)	43	52.60 (11.76)
Parents	100	63.62 (11.39)	57	64.28 (12.56)	43	67.74*(9.71)
Teachers	70	67.49*(14.44)	41	68.00*(16.71)	29	66.76*(10.69)
BRI						
Self-reports	100	59.66 (14.02)	57	63.12 (13.74)	43	55.07 (13.17)
Parents	100	63.62 (11.93)	57	63.07 (10.54)	43	64.35 (13.65)
Teachers	70	69.93*(18.63)	42	72.67*(18.97)	28	65.82*(17.64)
MI						
Self-reports	100	65.56*(12.67)	57	68.95*(11.22)	57	61.07 (13.20)
Parents	100	68.90*(10.15)	57	70.04*(10.46)	43	67.40*(9.64)
Teacher	68	76.76*(14.91)	40	74.70*(15.63)	28	79.71*(13.55)
GEC						
Self-reports	100	63.90 (13.15)	57	67.54*(12.07)	43	59.07 (13.10)
Parents	100	68.02*(10.43)	57	67.91*(9.98)	43	68.16*(11.12)
Teacher	68	76.26*(15.65)	40	75.65*(16.07)	28	77.14*(15.27)

Note GEC=Global Executive Composite, MI= Metacognitive Index, BRI= Behavior Regulation Index

*Means are considered clinically elevated with a defined T-score ≥ 65

Author Accepted Manuscript version of the paper by Andersen, Ann Christin et al in Child Neuropsychology, (2023), DOI 10.1080/09297049.2023.2174506

Figure 1: BRIEF T-scores, scales and indexes by informants



The overall correlations were medium between teacher and parent ratings for all indices (overall mean r= .44) and scales (overall mean r= .38) (Table 3). The correlation between teachers and self-reports was large (r= .58, p<.01) on the *Inhibit* scale, and medium (r= .38, p< .01) on the *Emotional Control* scale, but small on all other scales. The correlation between teachers and self-reports on the main indices and GEC varied from small (r=.14, not statistically significant) on the MI to medium on the BRI (r= .48, p< .01) and GEC (r=.31, p< .05). The correlation between parents and self-reports was large for all indices (mean r=.55), all statistically significant at the .01 level. The correlation was lowest on the *Monitor* scale (r=.41) and highest on the *Emotional Control* scale (r=.56).

Discrepancies in terms of differences in the BRIEF T-scores show that teachers rated adolescents as having greater problems than both parents and adolescents on all scales and indices (Table 3). Adolescents generally rated their problems lower than both parents and

Author Accepted Manuscript version of the paper by Andersen, Ann Christin et al in Child Neuropsychology (2023), DOI 10.1080/09297049.2023.2174506

Table 3. Pearson correlation coefficients and mean differences in T-scores for teacher-, parent- and self-ratings on BRIEF subscales and indexes.

BRIEF scales and indexes:	Informants	n	r	95% CI	Difference, mean	95% CI	p-value
Inhibit	Teacher-Parent	71	.46**	.25 to .62	1.55	-2.32 to 5.42	.43
	Parent-Self	100	.49**	.33 to .63	1.90	-.87 to 4.67	.18
	Teacher-Self	71	.58**	.41 to .72	6.28	2.93 to 9.63	<.001**
Shift	Teacher-Parent	69	.42**	.20 to .60	11.06	6.37 to 15.75	<.001**
	Parent-Self	100	.42**	.24 to .57	4.47	1.83 to 7.11	.001**
	Teacher-Self	69	.25*	.01 to .46	16.39	11.02 to 21.76	<.001**
Emotional Control	Teacher-Parent	70	.47**	.26 to .63	4.53	.33 to 8.73	.035*
	Parent-Self	100	.56**	.41 to .68	4.92	2.56 to 7.28	<.001**
	Teacher-Self	70	.38**	.16 to 56	10.73	6.13 to 15.32	<.001**
Initiate [a]	Teacher-Parent	71	.25*	.02 to .46	9.62	5.93 to 13.31	<.001**
Working memory	Teacher-Parent	70	.33**	.10 to .52	6.11	2.41 to 9.82	.002**
	Parent-Self	100	.45**	.28 to .60	6.38	4.04 to 8.72	<.001**
	Teacher-Self	70	.20	-.03 to .42	14.89	10.62 to 19.15	<.001**
Plan-Organize	Teacher-Parent	69	.46**	.25 to .63	5.41	2.09 to 8.72	.002**
	Parent-Self	100	.53**	.37 to .65	8.62	6.41 to 10.83	<.001**
	Teacher-Self	69	.21	-.03 to .43	16.59	12.45 to 20.74	<.001**
Organization of Materials	Teacher-Parent	69	.14	-.10 to .36	9.33	4.01 to 14.66	<.001**
	Parent-Self	100	.52**	.36 to .65	-.58	-2.82 to 1.66	.61

	Teacher-Self	69	-.001	-.24 to .24	9.99	4.06 to 15.91	.001**
Monitor	Teacher-Parent	70	.47**	.26 to .63	1.19	-2.01 to 4.38	.46
	Parent-Self	100	.41**	.23 to .56	8.28	5.73 to 10.83	<.001**
	Teacher-Self	70	.48**	.27 to .64	12.91	9.63 to 16.20	<.001**
BRI	Teacher-Parent	70	.49**	.29 to 65	5.37	1.44 to 9.30	.008**
	Parent-Self	100	.57**	.42 to 69	3.96	1.54 to 6.38	.002**
	Teacher-Self	70	.48**	.27 to .64	11.39	7.28 to 15.49	<.001**
MI	Teacher-Parent	68	.38**	.16 to .57	6.0	2.55 to 9.45	<.001**
	Parent-Self	100	.55**	.39 to .67	3.34	1.14 to 5.54	.003**
	Teacher-Self	68	.14	-.10 to .37	12.01	7.58 to 16.45	<.001**
GEC	Teacher-Parent	68	.46**	.25 to .63	6.57	3.14 to 10.00	<.001**
	Parent-Self	100	.54**	.38 to .67	4.12	1.82 to 6.42	<.001**
	Teacher-Self	68	.31*	.07 to .51	13.47	9.31 to 17.63	<.001**

Note. BRIEF= Behavior Rating Inventory of Executive Functioning, SD= Standard Deviation, CI= Confidence Interval, BRI= Behavior Regulation index, MI= Metacognitive index, GEC= Global Executive Composite

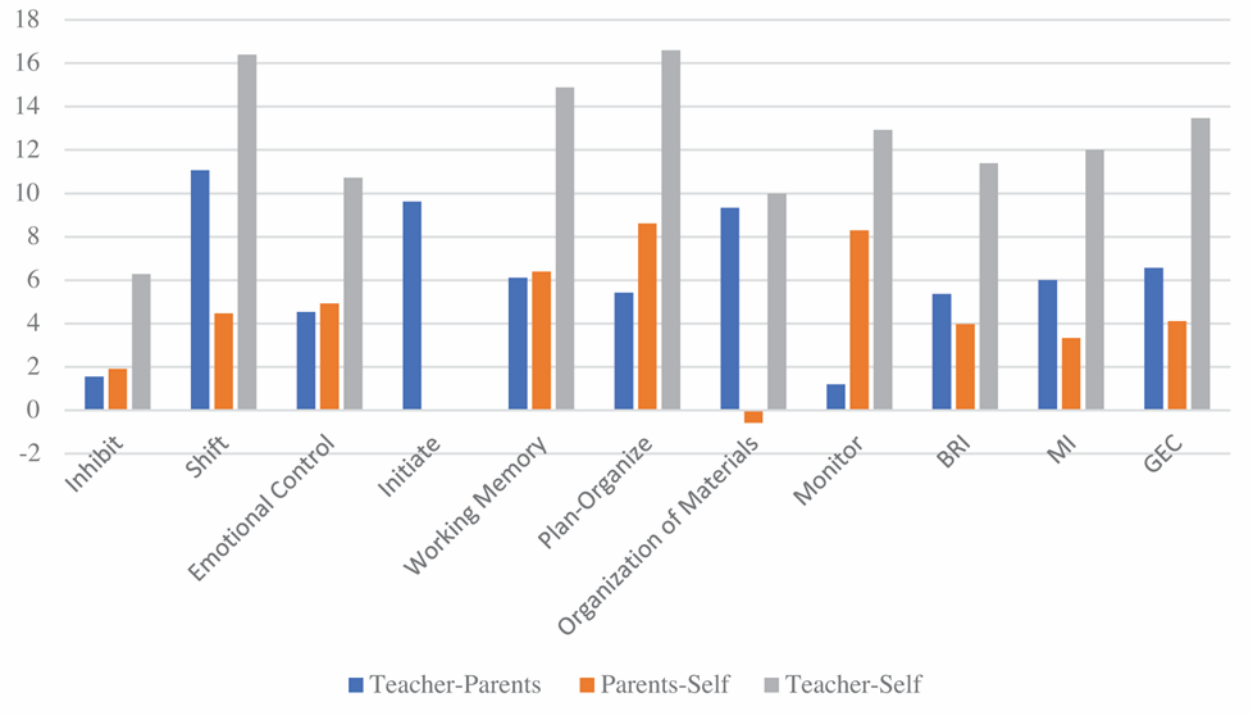
[a] only rated on parent and teacher forms.

*Significant at the .05 level

**Significant at the .01 level

teachers, with the exception of the *Organization of Materials* scale, but agreement was generally better between adolescents and their parents compared to both adolescents and teachers and parents and teachers. Agreements were highest among female participants and their parents and lowest among male participants and their teachers (Table 2). The mean differences between the informants are shown in Figure 2.

Figure 2 Discrepancy scores between different informants



Discussion

In this study, we aimed to describe problem profiles and informant discrepancies in behavioural EFs as measured by the BRIEF in 100 adolescents diagnosed with and treated for ADHD. Overall, our study shows that the study participants still experienced considerable EFDs despite standard treatment including medication. This study adds to the limited knowledge on the developmental trajectories of ADHD and supports previous findings on the

persistence of EFDs in adolescence and young adulthood for many of these patients despite treatment (Dvorsky & Langberg, 2019; Fossum et al., 2021; Zelazo & Carlson, 2012). The levels of reported EFDs were comparable and on some scales somewhat higher than those reported in previous Norwegian clinical populations (Sørensen & Hysing, 2014). This is most likely explained by our study population, which comprised adolescents still impaired after standard treatment and thus likely to represent a selection of ADHD patients with a complex phenotype (Coxe et al., 2021).

The highest levels of EFDs were reported on the scales comprising the MI. The *Working Memory*, *Initiate,* and *Plan/Organize* scales all have high ratings, which is consistent with previous findings of EF profiles in a clinical ADHD population (Jacobson et al., 2020; Skogli et al., 2013). These difficulties are likely to play an important role in daily functioning, not only academically but also socially. Interventions targeting executive dysfunction in these areas should be considered for this population. Compared to other studies reporting clinical profiles on the BRIEF subscales and indices in children with ADHD, our sample showed lower ratings on the *Inhibit* and *Shift* scales (Gioia, Isquith, Kenworthy, et al., 2002; Jacobson et al., 2020). This might be partly explained by the mean age being considerably higher in our study, and the participants might thus be more mature than those in comparable studies. The *Shift* scale, and partly the *Emotional Control* scale, were rated substantially higher in teacher reports than in adolescent and parent reports. A possible explanation for this might be that adolescents are more distressed at school than at home. Again, this might be related to the high level of comorbidity of emotional disorders in our sample, a subgroup important to be aware of when targeting interventions. The scales comprising the BRI were mostly at a subclinical level, except for teacher reports. This is also in contrast to the findings of previous studies on children with ADHD (Gioia et al., 2000b; Jacobson et al., 2020). A possible explanation for this might be that our study sample

comprised few participants with conduct disorders and no participants with primarily hyperactive-impulsive subtypes, as these clinical subtypes are likely to exhibit more emotional and behavioural regulation problems (Jacobson et al., 2020). Inattentive symptoms are more likely to persist into adolescence and adulthood, whereas hyperactive-impulsive symptoms tend to be less frequent with age (Franke et al., 2018). Inattentive subtypes with less hyperactive/impulsive symptom profiles, as well as more internalising versus externalising comorbidities are also more common in females with ADHD (Coxe et al., 2021; Hinshaw et al., 2012).

We found that both the correlations and mean T-scores varied between informants. Informant discrepancy may have several possible explanations, and there is no "true value" as these measures are subjective in nature. Differences may reflect different contexts of observation, understanding of causes of an observed behaviour and/or informants' perspectives on symptoms that require treatment (De Los Reyes & Kazdin, 2005). Teachers reported the highest degree of EFDs with clinically elevated T-scores on almost all scales and indices. This is consistent with previous findings and might be related to differences in the context of observation with higher demands on EF, making deficits more visible in the classroom than in the home environment (Mares et al., 2007; Soriano-Ferrer et al., 2014). It is also likely that teachers have a better reference for normality as they interact with students daily, in contrast to parents, who often have limited possibilities for comparison with non-ADHD children (Soriano-Ferrer et al., 2014). These findings are in contrast to the results from a study on a normative sample referred to in the BRIEF manual, where, in general, parents rated their children as having more problems on all scales as compared to teacher ratings (Gioia et al., 2000b). These differences in findings between different samples only emphasise the challenges adolescents with ADHD face in academic settings.

Participants in our study self-reported less EFDs than their parents and teachers did. There is evidence of less self-awareness in adolescents with ADHD as they tend to overestimate their EF abilities (Steward et al., 2017). Previous findings also suggest that parents and teachers are better observers of real-life functioning than adolescents with ADHD, especially males (Hoza et al., 2002). This positive illusory bias in adolescents with ADHD might influence treatment susceptibility, both regarding compliance to medication and the effects of behavioural interventions. Informant discrepancies were also found to predict poorer treatment responses (Hennig et al., 2018). Despite positive self-perception, children with ADHD tend to perform worse and give up more easily on challenging tasks than normally developed children (Hoza et al., 2001). Awareness of one's own impairments is an important prerequisite for changing one's own behaviour, which is important to consider when planning clinical approaches and treatment interventions for this group of patients (Volz-Sidiropoulou et al., 2016).

The present study has several strengths, the most important being the assessments by multiple informants. The study population was also heterogeneous in terms of comorbidities and symptom severity, which is representative of the population of adolescents with ADHD. However, this study had several limitations. First, the selection of participants for this study was not random as they were recruited for a clinical trial. This limits the generalisability of our findings. Second, there was a lack of comparison group. Third, the study was not powered for further analysis of subgroups, such as ADHD subtype or comorbidities.

Conclusion

We observed significant residual EFDs in a clinical sample of adolescents previously treated for ADHD. Our findings suggest that, in addition to parent and adolescent self-reports, it is valuable to include teacher reports in clinical evaluations to provide a broader picture of

EFDs. Although further research is needed, there are indications that EFDs play an important role in predicting functional impairment in ADHD (Biederman et al., 2006; Dvorsky & Langberg, 2019; Halleland et al., 2019). Identifying and tailoring treatments for these deficits might improve the future prognosis of this group of patients. However, the challenge remains that self-awareness and motivation for such interventions may need to be addressed to improve effectiveness.

Acknowledgements

Ethical information:

The Regional Committee for Medical and Health Ethics in South-East Norway approved the study protocol (2015/2115). We obtained written consent from all participants before enrollment and parental consent for participants under 16 years of age.

Study Funding:

The first author received a PhD grant from the Central Norway Regional Health Authority in 2018. The trial received additional funding from the CAP Clinic, St. Olav's Hospital; the Regional Competence Centre for Child and Youth Mental Health and Child Welfare (RKBU), Norwegian University of Science and Technology (NTNU); Regional Network for Autism, ADHD, and Tourette syndrome, Mid-Norway Health Trust; The National Research Network for ADHD, Ullevål University Hospital, Oslo, and the Regional Competence Network for ADHD, RKBU, NTNU.

Disclosure of interests:

AMS has received travel support and congress fee from MEDICE in the last 3 years. PHT has received speaker's fee from MEDICE and Shire in the last 3 years. ALJH has received travel support and a speaker's fee from MEDICE the last year. TSN has received travel support from MEDICE in the last year. ACA and SL declares no conflicts of interests.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders, 5th Edition, DSM-5*. American Psychiatric Publishing.

Arnold, L. E., Hodgkins, P., Kahle, J., Madhoo, M., & Kewley, G. (2020). Long-Term Outcomes of ADHD: Academic Achievement and Performance. *Journal of Attention Disorders*, *24*(1), 73-85. https://doi.org/10.1177/1087054714566076

Barkley, R. A., & Fischer, M. (2011). Predicting impairment in major life activities and occupational functioning in hyperactive children as adults: Self-reported executive function (EF) deficits versus EF tests. *Developmental Neuropsychology*, *36*(2), 137-161. https://doi.org/10.1080/87565641.2010.549877

Barkley, R. A., Fischer, M., Smallish, L., & Fletcher, K. (2002). The persistence of attention-deficit/hyperactivity disorder into young adulthood as a function of reporting source and definition of disorder. *Journal of Abnormal Psychology*, *111*(2), 279-289.

Biederman, J., Monuteaux, M. C., Doyle, A. E., Seidman, L. J., Wilens, T. E., Ferrero, F., Morgan, C. L., & Faraone, S. V. (2004). Impact of Executive Function Deficits and Attention-Deficit/Hyperactivity Disorder (ADHD) on Academic Outcomes in Children. *Journal of Consulting and Clinical Psychology*, *72*(5), 757-766. https://doi.org/10.1037/0022-006X.72.5.757

Biederman, J., Petty, C., Fried, R., Fontanella, J., Doyle, A. E., Seidman, L. J., & Faraone, S. V. (2006). Impact of psychometrically defined deficits of executive functioning in adults with attention deficit hyperactivity disorder. *American Journal of Psychiatry*, *163*(10), 1730-1738. https://doi.org/10.1176/ajp.2006.163.10.1730

Chan, E., Fogler, J. M., & Hammerness, P. G. (2016). Treatment of Attention-Deficit/Hyperactivity Disorder in Adolescents: A Systematic Review. *JAMA*, *315*(18), 1997-2008. https://doi.org/10.1001/jama.2016.5453

Chan, T., & Martinussen, R. (2015). Positive Illusions? The Accuracy of Academic Self-Appraisals in Adolescents With ADHD. *Journal of Pediatric Psychology*, *41*(7), 799-809. https://doi.org/10.1093/jpepsy/jsv116

Cohen, J. (1992). Statistical Power Analysis. *Current Directions in Psychological Science*, *1*(3), 98-101. https://doi.org/10.1111/1467-8721.ep10768783

Coxe, S., Sibley, M. H., & Becker, S. P. (2021). Presenting problem profiles for adolescents with ADHD: Differences by sex, age, race, and family adversity. *Child and Adolescent Mental Health*, *26*(3), 228-237. https://doi.org/https://doi.org/10.1111/camh.12441

De Los Reyes, A., & Kazdin, A. E. (2005). Informant discrepancies in the assessment of childhood psychopathology: A critical review, theoretical framework, and recommendations for further study. *Psychological Bulletin*, *131*(4), 483-509. https://doi.org/10.1037/0033-2909.131.4.483

Du Rietz, E., Cheung, C. H. M., McLoughlin, G., Brandeis, D., Banaschewski, T., Asherson, P., & Kuntsi, J. (2016). Self-report of ADHD shows limited agreement with objective markers of persistence and remittance. *Journal of Psychiatric Research*, *82*, 91-99. https://doi.org/https://doi.org/10.1016/j.jpsychires.2016.07.020

DuPaul, G., Power, T., Anastopoulos, A., & Reid, R. (2016). *ADHD rating scale-5 for children and adolescents: Checklists, norms, and clinical interpretation*. Guilford Press.

Dvorsky, M. R., & Langberg, J. M. (2019). Predicting Impairment in College Students With ADHD: The Role of Executive Functions. *Journal of Attention Disorders*, *23*(13), 1624-1636. https://doi.org/10.1177/1087054714548037

Fossum, I. N., Andersen, P. N., Øie, M. G., & Skogli, E. W. (2021). Development of executive functioning from childhood to young adulthood in autism spectrum disorder and attention-deficit/hyperactivity disorder: A 10-year longitudinal study. *Neuropsychology*, *35*(8), 809-821. https://doi.org/10.1037/neu0000768

Franke, B., Michelini, G., Asherson, P., Banaschewski, T., Bilbow, A., Buitelaar, J. K., Cormand, B., Faraone, S. V., Ginsberg, Y., Haavik, J., Kuntsi, J., Larsson, H., Lesch, K. P., Ramos-Quiroga, J. A., Réthelyi, J. M., Ribases, M., & Reif, A. (2018). Live fast, die young? A review on the developmental trajectories of ADHD across the lifespan. *European Neuropsychopharmacology*, *28*(10), 1059-1088. https://doi.org/10.1016/j.euroneuro.2018.08.001

Gioia, G. A., Isquith, P. K., Guy, S. C., & Kenworthy, L. (2000a). Behavior Rating Inventory of Executive Function. (Odessa,FL: Psychological Assessment Resources)

Gioia, G. A., Isquith, P. K., Guy, S. C., & Kenworthy, L. (2000b). *Behavior Rating Inventory of Executive Function Professional Manual*. Psychological Assessment Resources.

Gioia, G. A., Isquith, P. K., Kenworthy, L., & Barton, R. M. (2002). Profiles of everyday executive function in acquired and developmental disorders. *Child Neuropsychology*, *8*(2), 121-137. https://doi.org/10.1076/chin.8.2.121.8727

Gioia, G. A., Isquith, P. K., Retzlaff, P. D., & Espy, K. A. (2002). Confirmatory Factor Analysis of the Behavior Rating Inventory of Executive Function (BRIEF) in a Clinical Sample. *Child Neuropsychology*, *8*(4), 249-257. https://doi.org/10.1076/chin.8.4.249.13513

Guy, S. C., Isquith, P. K., & Gioia, G. A. (2004). *Behavior rating inventory of executive function-self-report version professional manual*. Psychological Assessment Resources.

Guy, W. (1976). *ECDEU assesment manual for psychopharmacology* (Vol. 76). US Department of Health, Education, and Welfare, Public Health Service, Alcohol, Drug Abuse, and Mental Health Administration, National Institute of Mental Health, Psychopharmacology Research Branch, Division of Extramural Research Programs.

Halleland, H. B., Sørensen, L., Posserud, M. B., Haavik, J., & Lundervold, A. J. (2019). Occupational Status Is Compromised in Adults With ADHD and Psychometrically Defined Executive Function Deficits. *Journal of Attention Disorders*, *23*(1), 76-86. https://doi.org/10.1177/1087054714564622

Halvorsen, M., Mathiassen, B., Amundsen, T., Ellingsen, J., Brøndbo, P. H., Sundby, J., Steinsvik, O. O., & Martinussen, M. (2019). Confirmatory factor analysis of the behavior rating inventory of executive function in a neuro-pediatric sample and its application to mental disorders. *Child Neuropsychology*, *25*(5), 599-616. https://doi.org/10.1080/09297049.2018.1508564

Haugan, A.-L. J., Sund, A. M., Young, S., Thomsen, P. H., Lydersen, S., & Nøvik, T. S. (2022). Cognitive behavioural group therapy as addition to psychoeducation and pharmacological treatment for adolescents with ADHD symptoms and related impairments: A randomised controlled trial. *BMC Psychiatry*, *22*(1), 375. https://doi.org/10.1186/s12888-022-04019-6

Helsedirektoratet. (2016, 04 may 2022). *ADHD Nasjonal faglig retningslinje*. Helsedirektoratet. Retrieved 09 from https://www.helsedirektoratet.no/retningslinjer/adhd#!

Hennig, T., Schramm, S. A., & Linderkamp, F. (2018). Cross-informant disagreement on behavioral symptoms in adolescent attention-deficit/hyperactivity disorder and its impact on treatment effects. *European Journal of Psychological Assessment*, *34*(2), 79-86. https://doi.org/10.1027/1015-5759/a000446

Hinshaw, S. P., Owens, E. B., Zalecki, C., Huggins, S. P., Montenegro-Nevado, A. J., Schrodek, E., & Swanson, E. N. (2012). Prospective follow-up of girls with attention-deficit/hyperactivity disorder into early adulthood: Continuing impairment includes elevated risk for suicide attempts and self-injury. *Journal of Consulting and Clinical Psychology*, *80*(6), 1041-1051. https://doi.org/10.1037/a0029451

Hoza, B., Pelham, W. E., Jr., Dobbs, J., Owens, J. S., & Pillow, D. R. (2002). Do boys with attention-deficit/hyperactivity disorder have positive illusory self-concepts? *Journal of Abnormal Psychology*, *111*(2), 268-278. https://doi.org/10.1037//0021-843x.111.2.268

Hoza, B., Waschbusch, D. A., Owens, J. S., Pelham, W. E., & Kipp, H. (2001). Academic task persistence of normally achieving ADHD and control boys: Self-evaluations, and attributions.

Journal of Consulting and Clinical Psychology, *69*(2), 271-283. https://doi.org/10.1037/0022-006X.69.2.271

Jacobson, L. A., Pritchard, A. E., Koriakin, T. A., Jones, K. E., & Mahone, E. M. (2020). Initial Examination of the BRIEF2 in Clinically Referred Children With and Without ADHD Symptoms. *J Atten Disord*, *24*(12), 1775-1784. https://doi.org/10.1177/1087054716663632

Jacobson, L. A., Williford, A. P., & Pianta, R. C. (2011). The role of executive function in children's competent adjustment to middle school. *Child Neuropsychology*, *17*(3), 255-280. https://doi.org/10.1080/09297049.2010.535654

Jensen, C. M., & Steinhausen, H. C. (2015). Comorbid mental disorders in children and adolescents with attention-deficit/hyperactivity disorder in a large nationwide study. *Attention Deficit Hyperactivity Disorders*, *7*(1), 27-38. https://doi.org/10.1007/s12402-014-0142-1

Kaufman, J., Birmaher, B., Brent, D., Rao, U., Flynn, C., Moreci, P., Williamson, D., & Ryan, N. (1997). Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime Version (K-SADS-PL): initial reliability and validity data. *Journal of the American Academy of Child and Adolescent Psychiatry*, *36*(7), 980-988. https://doi.org/10.1097/00004583-199707000-00021

Krieger, V., & Amador-Campos, J. A. (2018). Assessment of executive function in ADHD adolescents: contribution of performance tests and rating scales. *Child Neuropsychology*, *24*(8), 1063-1087. https://doi.org/10.1080/09297049.2017.1386781

Køhn, K., & Halvorsen, M. (2020). Måleegenskaper ved den norske laererversjonen av Behavior Rating Inventory of Executive Function (BRIEF). https://doi.org/10.21337/0069

Lantrip, C., Isquith, P. K., Koven, N. S., Welsh, K., & Roth, R. M. (2016). Executive Function and Emotion Regulation Strategy Use in Adolescents. *Applied Neuropsychology: Child*, *5*(1), 50-55. https://doi.org/10.1080/21622965.2014.960567

Mares, D., McLuckie, A., Schwartz, M., & Saini, M. (2007). Executive function impairments in children with attention-deficit hyperactivity disorder: do they differ between school and home environments? *Canadian Journal of Psychiatry. Revue Canadienne de Psychiatrie*, *52*(8), 527-534. https://doi.org/10.1177/070674370705200811

Nøvik, T. S., Haugan, A. J., Lydersen, S., Thomsen, P. H., Young, S., & Sund, A. M. (2020). Cognitive-behavioural group therapy for adolescents with ADHD: Study protocol for a randomised controlled trial. *BMJ Open*, *10*(3), e032839. https://doi.org/10.1136/bmjopen-2019-032839

Posner, J., Polanczyk, G. V., & Sonuga-Barke, E. (2020). Attention-deficit hyperactivity disorder. *The Lancet*, *395*(10222), 450-462. https://doi.org/10.1016/S0140-6736(19)33004-1

Shaffer, D., Gould, M. S., Brasic, J., Ambrosini, P., Fisher, P., Bird, H., & Aluwahlia, S. (1983). A children's global assessment scale (CGAS). *Archives of General Psychiatry*, *40*(11), 1228-1231. https://doi.org/10.1001/archpsyc.1983.01790100074010

Sibley, M. H., Swanson, J. M., Arnold, L. E., Hechtman, L. T., Owens, E. B., Stehli, A., Abikoff, H., Hinshaw, S. P., Molina, B. S. G., Mitchell, J. T., Jensen, P. S., Howard, A. L., Lakes, K. D., & Pelham, W. E. (2017). Defining ADHD symptom persistence in adulthood: Optimizing sensitivity and specificity. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *58*(6), 655-662. https://doi.org/10.1111/jcpp.12620

Skogli, E. W., Teicher, M. H., Andersen, P. N., Hovik, K. T., & Øie, M. (2013). ADHD in girls and boys--gender differences in co-existing symptoms and executive function measures. *BMC Psychiatry*, *13*, 298. https://doi.org/10.1186/1471-244x-13-298

Soriano-Ferrer, M., Félix-Mateo, V., & Begeny, J. C. (2014). Executive Function Domains among Children with ADHD: Do they Differ between Parents and Teachers Ratings? *Procedia - Social and Behavioral Sciences*, *132*, 80-86. https://doi.org/https://doi.org/10.1016/j.sbspro.2014.04.281

Steward, K. A., Tan, A., Delgaty, L., Gonzales, M. M., & Bunner, M. (2017). Self-Awareness of Executive Functioning Deficits in Adolescents With ADHD. *Journal of Attention Disorders*, *21*(4), 316-322. https://doi.org/10.1177/1087054714530782

Sørensen, L., & Hysing, M. (2014). Måleegenskaper ved den norske versjonen av Behavior Rating Inventory of Executive Function (BRIEF), foreldreversjonen. *Psyktestbarn*, *6*(2). https://doi.org/10.21337/0037

Toplak, M. E., Bucciarelli, S. M., Jain, U., & Tannock, R. (2008). Executive Functions: Performance-Based Measures and the Behavior Rating Inventory of Executive Function (BRIEF) in Adolescents with Attention Deficit/Hyperactivity Disorder (ADHD). *Child Neuropsychology*, *15*(1), 53-72. https://doi.org/10.1080/09297040802070929

Volz-Sidiropoulou, E., Boecker, M., & Gauggel, S. (2016). The Positive Illusory Bias in Children and Adolescents With ADHD: Further Evidence. *Journal of Attention Disorders*, *20*(2), 178-186. https://doi.org/10.1177/1087054713489849

Walker, J. M., & D'Amato, R. C. (2006). Test review: Behavior rating inventory of executive function-self-report version. *Journal of Psychoeducational Assessment*, *24*(4), 394-398.

Willcutt, E. G., Doyle, A. E., Nigg, J. T., Faraone, S. V., & Pennington, B. F. (2005). Validity of the Executive Function Theory of Attention-Deficit/Hyperactivity Disorder: A Meta-Analytic Review. *Biological Psychiatry*, *57*(11), 1336-1346. https://doi.org/https://doi.org/10.1016/j.biopsych.2005.02.006

World Health Organization. (1992). *The ICD-10 classification of mental and behavioural disorders: Clinical descriptions and diagnostic guidelines*. World Health Organization.

Zelazo, P. D., & Carlson, S. M. (2012). Hot and Cool Executive Function in Childhood and Adolescence: Development and Plasticity. *Child Development Perspectives*, *6*(4), 354-360. https://doi.org/https://doi.org/10.1111/j.1750-8606.2012.00246.x