Journal of Child and Family Studies (2018) 27:1661–1670
https://doi.org/10.1007/s10826-017-0999-7

ORIGINAL PAPER

Pediatric Depression Symptoms, Executive Functioning Weaknesses, and Associated Neuropsychological and Psychiatric Outcomes

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Published online: 5 January 2018

Abstract

Despite numerous studies in adults, only a handful of studies have examined executive functioning (EF) in childhood depression. Our study examined the relationship between significant depressive symptoms and an EF weakness in a child inpatient psychiatric setting. A medical chart review was conducted for 98 ethnically diverse 6- to 12-year-old boys and girls, who received a neuropsychological evaluation during their psychiatric inpatient hospitalization. Children were classified as having depressive symptoms if they had a T-Score 1.5 SD above the mean on at least 1 subdomain of the Childhood Depression Inventory and classified as having an EF weakness if they had a T-score 1.5 SD below the mean on at least 1 test of executive functioning. Results indicated that compared to children with either depressive symptoms only or only an EF weakness, children with both depressive symptoms and an EF weakness had poorer cognitive test performance on a measure of immediate memory ($F(2,72) = 4.07$, $p = .000$; Cohen's $d = -.83$ and $-.90$, respectively) and longer hospitalizations stay ($F(2,93) = 4.04$, $p = .021$; Cohen's $d = .54$ and .62, respectively). Additionally, children with both depressive symptoms and an EF weakness had higher rates of ADHD than children with depressive symptoms only (OR = 2.11) and higher rates of EF weaknesses than children with only an EF weakness ($t(60) = 2.54$, $p = .014$; Cohen's $d = .68$). Results suggest that not all children with depressive symptoms have an EF weakness; however, children who present with this comorbidity are at risk for more cognitive difficulties and significant psychiatric outcomes including prolonged hospitalizations.

Keywords Children, Depression · Executive dysfunction · Inpatient · Length of stay

Depressive symptoms and executive functioning weaknesses commonly co-occur (Snyder 2013). Executive functioning (EF) refers to a set of top-down mental skills required for higher-order cognitive processes (Gilbert and Burgess 2008). Traditionally subsumed under this broad definition are EF sub-domains including: inhibition, initiation, persistence, cognitive flexibility, working memory, and reasoning/problem solving (Diamond 2013; Gilbert and Burgess 2008; Snyder 2013). An EF weakness can reflect difficulties with any of the EF sub-domains. Meta-analyses of adults have reported significant associations between depression and EF weaknesses such as reduced verbal fluency and set shifting abilities (Snyder 2013). However, differences in the manifestation of depression between adult and pediatric samples make it difficult to generalize findings from the adult depression literature to youth populations (Holler et al. 2014).

Data from pediatric populations support the co-occurrence of depressive symptoms and EF weaknesses. Wagner et al.'s (2015) meta-analysis of 17 studies of neuropsychological functioning among children and adolescents diagnosed with Major Depressive Disorder found that, compared to youths without depression, youths with depression demonstrated pronounced EF weaknesses in the

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sub-domains of verbal fluency, inhibition, set shifting, and planning. Findings from studies exclusively focused on depression in pre-adolescent children have mirrored Wagner et al.'s (2015) findings. For example, Kavanaugh et al. (2016) found that failure to maintain set predicted depressive disorder diagnoses in children aged 6–12 who were psychiatrically hospitalized. Likewise, Emerson et al. (2005) and Lundy et al. (2010) reported statistically significant associations between depressive symptoms and EF weaknesses, namely set shifting and flexibility difficulties in outpatient samples. Lundy et al. (2010) also found broader deficits in intellect, attention, processing speed, language, aspects of memory and learning, and motor skills (many of which involve executive functioning) among depressed youth.

However, unlike the adult literature where there appears to be consensus regarding the association between EF weaknesses and depressive symptoms, not all studies have found support for the relationship between EF weaknesses and depressive symptoms in children. Specifically, Vilgis et al. (2015) reviewed 33 studies and found little support for EF deficits among children and adolescents with dysthymia or depression. Inconsistencies in the literature may reflect the existence of a depression-executive dysfunction phenotype or syndrome, whereby only a portion of children with depression, regardless of symptom severity, experience co-occurring EF weaknesses (Alexopoulos 2002). Disparities in the broader child and adolescent EF-depression literature may also reflect a reliance on heterogeneous samples, such as wide age ranges among participants and varying definitions of both EF and depression (e.g., inclusion of dysthymia). Samples focused on groups displaying milder symptoms of depression (i.e., dysthymic youth), may decrease the likelihood of detecting EF weaknesses because cognitive deficits are often moderated by demographic and clinical factors such as psychiatric symptom severity (McDermott and Ebmeier 2009). Thus, less severe depressive symptomology might be associated with subtler EF difficulties; research on children with more severe psychopathology may improve the ability to detect EF deficits.

Limitations in recent research on depressive symptoms and EF indicate a need for continued investigations. Executive functions are crucial to mental and physical well-being, as well as adaptive, cognitive, social, and psychological development in childhood (Austin et al. 2001; Diamond 2013). More specifically, EF has been associated with global academic achievement of elementary school children (Fuhs et al. 2014). Among middle school youth, EF weaknesses predicted alcohol and cigarette use (Pentz et al. 2015). Better EF in early childhood predicted lower incidences of peer rejection and victimization at age 15 (Holmes et al. 2016). Given that depression diagnoses are the most frequent primary mental health diagnoses for childhood psychiatric hospitalizations, accounting for 44.1% (Bardach et al. 2014), obtaining a better understanding of the possible effects of co-morbid EF weaknesses among children with depressive symptoms is important. Additionally, understanding the impact of comorbidity of depressive symptoms and EF weaknesses is imperative because children with depression are already at higher risk for adverse outcomes such as poor academic achievement and difficulties with psychosocial functioning (Austin et al. 2001; Diamond 2013; Fleming and Offord 1990; Fröjd et al. 2008).

To advance our understanding of the effects of youth depressive symptoms with co-occurring EF weaknesses, we sought to evaluate the effects of co-morbid depressive symptomology and an EF weakness on clinical management outcomes (e.g., medication administered during hospitalization, length of stay on the inpatient unit, and hospital readmission) in a narrow, childhood-only age range (youths aged 6–12) with depressive symptomology within a psychiatric inpatient setting. Based on recommendations from the National Institute of Mental Health (NIMH), this study avoided dependence on DSM diagnostic classification. Rather, we focused on clinical symptomology in an attempt to be consistent with the NIMH's Research Domain Criteria (RDoC) project (Cuthbert and Insel 2013; Insel et al. 2010). Specifically, we focused on severity of depressive symptoms and executive functioning weaknesses in order to examine the association between these core constructs and the influence of their comorbidity on clinical outcomes. It was hypothesized that the three study groups (i.e., Dep-Only Group, EF Weakness -Only Group, Dep-EF Weakness Group, described in more detail below) would be similar in demographic status (e.g., age, sex, race, etc.). It was hypothesized that the group with co-morbid depressive symptoms and an EF weakness would demonstrate: (a) a greater number of hospital readmissions, (b) a longer length of stay on the inpatient unit, (c) more severe psychiatric presentation, and (d) poorer neurocognitive functioning.

Method

Participants

We obtained approval from the hospital's Research Protection Office IRB to conduct this study. An informed consent waiver was granted because: (1) the study was a retrospective medical chart review focused on existing measures and documents; (2) identifying information was not collected; (3) the research presented no more than minimal risk to the subjects; (4) a waiver for informed consent did not adversely impact the welfare and rights of the subjects; and (5) without a waiver for informed consent the research could

Table 1 Summary of demographic characteristics

	n	Dep-Only ($n = 36$)	EF Weakness-Only ($n = 24$)	Dep-EF Weakness ($n = 38$)	Significance test result	ES
Age	98	119.61 (21.20)	124.25 (19.57)	120.87 (19.67)	F (2,9) = .39, $p = .68$	*Eta squared* = .01
% Male	98	75.00%	83.33%	63.16%	X^2 (2) = 3.19, $p = .20$	Phi = .18
% White	79	66.66%	52.94%	62.50%	X^2 (2) = .87, $p = .65$	Phi = .11
Public insurance	90	63.33%	58.33%	63.89%	X^2 (2) = .21, $p = .90$	Phi = .05

*$p < .05$; **$p < .01$; ***$p < .001$

not be conducted practically. Clinical data were collected from a children's inpatient psychiatric program within a pediatric psychiatric hospital affiliated with a medical school. The program admits children aged 3–12, although most children referred for neuropsychological evaluation were 6–12 years old. Our study focused on children consecutively referred for a neuropsychological evaluation (total $n = 238$) between 2010 and 2015. The inclusion criteria for our study were: (1) children must have been between 6 and 12 years of age at the time of the neuropsychological evaluation, and (2) the children must have had a diagnosis of a mood or anxiety disorder assigned by a hospital psychiatrist. Children were excluded from the current study if there was not sufficient information available in hospital medical records to extract key variables including: (1) not completing a self-report measure of depressive symptoms, and (2) not completing three EF measures. Approximately 41% of children referred for neuropsychological evaluation met inclusion criteria ($n = 98$).

Procedures

All participants were referred by attending psychiatrists for a neuropsychological evaluation to characterize neurocognitive functioning and assist with treatment planning. Neuropsychological evaluations were typically conducted over several sessions and/or days depending on the child's functioning and tolerance for testing. Testing was carried out by a child clinical neuropsychologist (licensed psychologist), a psychometrician, and/or a graduate-level neuropsychology trainee under the supervision of the licensed psychologist. All scores were converted to standardized scores (e.g., T-scores, z-scores, etc.) for consistency. Test results were examined across several cognitive domains.

Measures

Visual-construction was assessed with the Beery Visual Motor Integration-Fifth Edition (Beery 2004) and the Rey Complex Figure Test-Copy Trial (Meyers and Meyers 1995). *Verbal memory* was assessed using the Wide Range Assessment of Memory and Learning-Second Edition (WRAML-2) including: Immediate, Delayed Recall, and Delayed Recognition Story Memory scores (Sheslow and Adams 2003). *Motor/psychomotor speed* was assessed with the Grooved Pegboard: Dominant Hand (time to completion) (Lafayette Instrument Company 2002) and Trail Making Test-A (time to completion) (Crowe 1998). *Verbal and perceptual intelligence* were assessed with the Wechsler Abbreviated Scale of Intelligence (WASI-I $n = 31$; WASI-II $n = 60$) vocabulary, similarities, block design or matrix reasoning subtests (Wechsler 1999, 2011) or Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV; $n = 4$) (Wechsler 2003) block design, similarities, digit span, picture concepts, coding, vocabulary, letter-number sequence, matrix reasoning, comprehension, and symbol search. *Executive functioning* was operationalized using the Stroop Color and Word Test: Children's version (Stroop C-W; time to completion), Trail Making Test-Part B (TMT-B; time to completion), and Controlled Oral Word Association Test: FAS Condition (COWAT-FAS). These EF measures have been included in previous studies of depressive symptoms (Alvarez and Emory 2006; Emerson et al. 2005; Vilgis et al. 2015). Stroop C-W assesses inhibition/interference (Alvarez and Emory 2006). The Trail-Making Test-Part B (TMT-B) assesses flexibility/set-shifting (Chaytor et al. 2006; Henry and Bettenay 2010). The COWAT-FAS task is a verbal fluency and initiation task, assessing effortful word retrieval (Chaytor et al. 2006; Henry and Bettenay 2010).

Sample size varied by neuropsychological measure as not all children completed the entire testing battery. For example, testing was occasionally disrupted or discontinued due to the nature of the inpatient unit such as children's limited attentional abilities, the child receiving visitors, and early discharge. Thus, longer measures with time-delayed components were generally administered less frequently and have smaller cell sizes (e.g. verbal memory $n = 75$).

Demographic characteristics of the sample included: age, sex, race, and use of public insurance (as a proxy for low socio-economic status) (see Table 1). Psychiatric variables included hospital length of stay (LOS; in days), whether the hospitalization was the child's first admission or was a re-admission to the hospital, and the presence of specific psychiatric and neurodevelopmental disorders diagnosed during hospitalization. Information on medication status at

the time of the neuropsychological evaluation was not consistently available; however, medication status at the time of admission was examined. The standard practice was for children to continue their existing medication regimes during their neuropsychological evaluation. Medications at intake were classified into mood stabilizers, anxiolytics, antipsychotics/atypical antipsychotics, anti-depressants (selective serotonin reuptake inhibitors and others [e.g., bupropion]), and stimulants/non-stimulants (stimulants [e.g., methylphenidate] and non-stimulants [e.g., guanfacine]). Mood disorders were categorized based on the psychiatric diagnosis assigned during clinical care and categorized as *Depressive Disorders* (Major Depressive Disorder, Dysthymic Disorder, and Depressive Disorder Not Otherwise Specified), *Bipolar Disorder*, and *Mood Disorders* (Mood Disorder Not Otherwise Specified and Disruptive Mood Dysregulation Disorder).

Self-report measures were used to assess anxiety, trauma, and depressive symptoms. Anxiety symptoms were assessed with the Multidimensional Anxiety Scale for Children (MASC), a 39-item (first edition) or 50 item (second edition) self-report questionnaire that assesses physical symptoms of anxiety, social anxiety, harm avoidance, and separation anxiety on a 4-point scale (ranging from 0-"never", to 3-"often") (March et al. 1997; March 2012). Ratings are then summed to provide an omnibus score indicating level of anxiety. Independent research suggests the MASC demonstrates good internal consistency and divergent validity from depression measures, such as the CDI (Muris et al. 2002). Trauma-related symptoms were assessed using the Trauma Symptom Checklist for Children (TSCC), a 54 item self-report measure (Briere 1996, pp. 253–258). All items are rated on a 4-point frequency scale and averaged across items. The test's manual reports favorable psychometric properties, such as good internal reliability and external validity (Briere 1996). The Children's Depression Inventory (CDI) is a 27-item measure that assesses depressive symptoms on a 3-point scale (Kovacs 1992). The Children's Depression Inventory- Second Edition (CDI-2) is a 28-item measure that assesses depressive symptoms on a 4-point scale (Kovacs, 2011). On both the CDI and CDI-2, item scores are summed and raw scores are converted to age-corrected T-scores for each of the four domains (Negative Mood/Physical Symptoms, Self-Esteem, Interpersonal Problems, and Ineffectiveness). Independent research indicates that the CDI demonstrates adequate specificity and sensitivity for identifying youth with depressive disorders (Timbremont et al. 2004).

Data Analyses

All neuropsychological test scores and psychological self-report scores were converted to age-corrected standardized scores. Anxiety symptoms and trauma symptom T-scores were included in the analyses as continuous variables. Children were classified as presenting with *Depressive Symptoms* if they obtained a T-score ≥1.5 standard deviations above the normative mean (i.e., T-score ≥65, which represents a clinically significant level of symptoms per the test manual) on at least one of the CDI subdomains (Negative Mood/Physical Symptoms, Self-Esteem, Interpersonal Problems, and Ineffectiveness). Following the work of Beauchamp et al.'s (2015) criteria for classifying neuropsychological impairment, an *EF weakness* was defined as a T-score ≥1.5 standard deviations below the normative mean on at least one of the executive measures (Stroop C-W, TMT-B, and COWAT-FAS).

One-way between-subject analyses of variance (ANOVAs), chi-squared tests of independence, and independent samples t-tests were used to assess for group differences across demographic, psychiatric, and cognitive variables. For the ANOVAs that revealed a statistically significant omnibus effect, follow-up Tukey pairwise comparisons were conducted. Multivariate analyses of variance (MANOVAs) were conducted for self-reported anxiety/trauma symptoms and neuropsychological variables, with follow-up comparisons (ANOVAs with post-hoc comparisons as needed) for statistically significant results. Effect sizes (Eta-square and phi for omnibus tests and Cohen's d for pairwise follow-ups) were calculated to characterize the magnitude of group differences and aid in the interpretation of results. Alpha levels were set at 0.05 for all analyses. Analyses were conducted using SPSS version 23.0.

Results

Group Composition

In the total sample, 36.7% of children had Depressive Symptoms-Only (Dep-Only; $n = 36$), 24.5% had an EF Weakness-Only (EF Weakness-Only; $n = 24$), and 38.8% had Depressive Symptoms and an EF Weakness (Dep-EF Weakness; $n = 38$). Considering the symptom overlap, half of the children with depressive symptoms in our sample (51.4%) also had an EF weakness. Approximately 60% of children with an EF weakness (61.3%) also presented with depressive symptoms.

Results of chi-square analyses indicated that all four of the CDI subscales were significantly different between the EF Weakness-Only group and the two groups with depressive symptoms (Dep-EF Weakness; Dep-Only, respectively): Negative Mood/Physical Symptoms [X^2 (1) = 13.620); $X^2(1) = 28.571$], Self-Esteem [X^2 (1) = 12.902; $X^2(1) = 15.814$], Interpersonal Problems [$X^2(1) = 20.773$; $X^2(1) = 28.571$], and Ineffectiveness [$X^2(1) = 29.393$; X^2

Table 2 Summary of group difference on psychiatric symptoms, length of stay, medication, and diagnoses

	n	1. Dep-Only ($n = 36$)	2. EF Weakness-Only ($n = 24$)	3. Dep-EF Weakness ($n = 38$)	t/ F/X^2	ES	Pairwise
Grouping variables							
CDI-2	73	72.54 (11.21)	–	68.39 (11.30)	1.58	.339	–
EF	62	–	−.96 (5.03)	−1.37 (.68)	2.54*	.68	–
Length of stay	98	18.42 (12.27)	16.88 (13.57)	30.42 (24.04)	5.753**	.108	1,2 < 3
Re-admission	97	10/36	6/24	15/37	2.077	.146	–
Intake medications							
Antidepressant	96	27.78%	25.00%	27.78%	.070	.027	–
Stim/non-stim.	96	41.67%	50.00%	61.11%	2.737	.169	–
Anti-psychotics	96	13.89%	37.50%	36.11%	5.789	.246	–
Mood Stabilizer	96	5.56%	4.17%	16.67%	3.637	.195	–
Diagnoses		M (SD)/%					
# of Dx	98	2.19 (.89)	2.38 (.97)	2.84 (.82)	5.224**	.099	1 < 3
Depressive	98	25.00%	16.67%	26.32%	.837	.092	–
Anxiety	98	47.22%	54.17%	68.42%	3.507	.189	–
AD/HD	98	58.33%	75.00%	84.21%	6.305*	.254	1 < 3
Behavioral	98	16.67%	20.83%	10.53%	1.287	.115	–
Bipolar	98	.00%	.00%	2.63%	1.595	.128	–
Mood	98	61.11%	62.50%	47.37%	1.943	.141	–
Psychotic	98	.00%	.00%	2.63%	1.595	.128	–
PDD/ASD	98	5.56%	4.17%	13.16%	2.102	.146	–
Learning	98	.00%	.00%	2.63%	1.595	.128	–
Language	98	2.78%	.00%	13.16%	5.538	.238	–
Tic	98	2.78%	.00%	10.53%	4.001	.202	–

1 = Dep-Only Group, 2 = EF Weakness-Only Group, 3 = Dep-EF Weakness Group; ES = Effect Size: Cohen's d for t tests, phi for chi-squared, and partial eta-squared for ANOVA

*$p < .05$; **$p < .01$; ***$p < .001$

(1) = 23.158]. The Dep-EF Weakness and the Dep-Only groups were significantly more likely to have elevations across all four CDI subscales. Thus, a single CDI subscale elevation was not driving group assignment, but rather elevations across all four subscales were responsible for the groupings. Chi-square analyses indicated no differences between the Dep-Only and Dep-EF Weakness group in three of the four CDI subscales. However, the Dep-Only group was more likely to report elevations on the negative mood/physical symptoms subscale [$X^2(1) = 5.592$].

Similarly, results of chi-square analyses indicated that all three measures of EF functioning, Stroop C-W [$X^2(1) = 37.974$; $X^2(1) = 41.707$], COWAT-FAS [$X^2(1) = 17.823$; $X^2(1) = 13.846$], TMT-B [$X^2(1) = 17.823$; $X^2(1) = 4.737$], were significantly different between the Dep-Only group and the two groups with an EF Weakness (Dep-EF Weakness; EF-Weakness Only). The Dep-EF Weakness and the EF-Weakness Only groups were significantly more likely to have elevations across all three measures. Thus, a single EF measure was not accounting for group assignment, but rather elevations across all three measures were responsible for the groupings. Chi-square analyses indicated no differences between the EF Weakness-Only and the Dep-EF Weakness group in two of the three EF measures (Stroop C-W and COWAT-FAS). However, the Dep-EF group was more likely to have slower time to completion on TMT-B [$X^2(1) = 5.194$].

Symptom Reporting

Given that the CDI was used to form groups, we restricted our comparison of CDI total scores to the two groups with elevated depressive symptoms to examine whether a comorbid EF weakness was associated with higher depressive symptoms. There were no differences in depressive symptomology between the Dep-EF Weakness and Dep-Only groups (see Table 2).

Results from MANOVAs revealed significant group differences in trauma-related symptoms $F(2,86) = 7.80$,

Table 3 Multivariate analysis of variance (MANOVA) results for symptomology and neurocognitive functioning

					Whole sample ($n = 98$)		
	n	Dep-Only ($n = 36$)	Executive-Only ($n = 24$)	Dep-Executive ($n = 38$)	F	Partial eta-sq.	Pairwise[a]
Self-report MANOVA (single step)					4.609***	.100	
TSCC	89	57.85 (12.60)	45.67 (10.76)	56.06 (11.40)	7.798***	.157	2 < 1,3
MASC	96	57.89 (11.69)	48.04 (9.57)	57.27 (11.98)	6.990**	.143	2 < 1,3
Intelligence					2.216	.048	
Verbal IQ	92	−.10 (.83)	−.44 (1.00)	−.73 (.82)	4.482*	.092	1 > 3
Perceptual IQ	92	−.23 (.95)	−.34 (.99)	−.59 (.85)	1.454	.032	
Motor					.192	.004	
TMT A	94	.10 (1.27)	−.12 (1.31)	−.12 (1.19)	.350	.008	
Pegboard	94	−.58 (2.05)	−.75 (1.27)	−.81 (1.99)	.133	.003	
Verbal memory					4.071**	.103	
Immediate	75	−.09 (1.03)	−.29 (.87)	−1.08 (1.02)	7.571**	.174	1,2 > 3
Delayed	75	−.22 (1.09)	−.49 (1.16)	−1.23 (.78)	7.674**	.176	1 > 3
Construction					1.186	.029	
VMI	84	−.16 (1.00)	−.25 (1.10)	−.65 (.94)	2.076	.049	
RCFT	84	−.76 (1.17)	−1.03 (1.71)	−1.22 (1.30)	.908	.022	

*$p < .05$; **$p < .01$; ***$p < .001$[a]

1 = Dep-Only Group, 2 = EF Weakness-Only Group, 3 = Dep-EF Weakness Group

$p = .001$ and anxiety $F(2,93) = 6.99$, $p = .002$ (see Table 3). Pairwise comparisons revealed that children with a Dep-EF Weakness and children with Dep-Only endorsed significantly more trauma related symptoms (Cohen's $d = 0.94$; $d = 1.04$, respectively) and anxiety symptoms (Cohen's $d = 0.85$, $d = 0.92$, respectively) than children with an EF Weakness-Only. There were no significant differences in self-reported trauma symptoms and anxiety between children in the Dep-EF Weakness group and children in the Dep-Only groups.

Executive Functioning

Given that executive functioning tests results were used to form groups, we restricted our comparisons of executive functioning test results to the two groups with an elevated EF weakness to examine whether comorbid depressive symptoms were associated with worse EF test performance. Results from independent samples t-tests that examined performance on neuropsychological measures indicated that children with Dep-EF Weakness had significantly more EF difficulties than children in the EF Weakness-Only group ($t(60) = 2.54$, $p = .014$, Cohen's $d = .68$). The medium effect size may suggest practical significance for the additional EF challenges for children in the Dep-EF Weakness relative to children in the EF Weakness-Only group (Cohen 1988).

Neuropsychological Functioning

MANOVA results revealed significant differences in Memory $F(2,72) = 4.07$, $p = .000$. Specifically, pairwise comparisons indicated that children with a Dep-EF Weakness performed worse on the measure of immediate memory, compared to children with an EF Weakness-Only (Cohen's $d = -0.90$) and Dep-Only (Cohen's $d = -0.83$). Children with a Dep-EF Weakness performed worse on a measure of Delayed Story Memory than children in the Dep-Only group (Cohen's $d = -1.07$). No differences were detected between groups in terms of overall intelligence, motor, or constructional skills as shown in Table 3.

Psychiatric Outcomes

Two children had hospital stays greater than 100 days. After removing these outliers, ANOVA analyses indicated significant group differences in length of stay $F(2,93), = 4.04$, $p = .021$. Pairwise analyses indicated that children with a Dep-EF Weakness ($M = 26.17$ days, SD = 16.04) were hospitalized for significantly longer than children with Dep-Only ($M = 18.42$, SD = 12.27; Cohen's $d = 0.54$) and an EF Weakness-Only ($M = 16.88$, SD = 13.57, Cohen's $d = 0.62$). These differences represented medium effects. There were no significant group differences in re-admission status or medications at hospital admission among the groups.

Findings for Children with ADHD

Results of ANOVAs revealed statistically significant differences among groups in terms of the number of diagnoses $F(2,95) = 5.22$, $p = 0.007$. This finding was driven by significant differences between the groups in terms of rates of Attention-Deficit/Hyperactivity Disorder (ADHD). Pairwise comparisons indicated that the Dep-EF Weakness group had higher rates of ADHD (84.2%, $n = 32$) than the Dep-Only group (58.3%, $n = 18$, OR = 2.11). To control for the effects of ADHD, ANOVAs and pairwise comparisons were recalculated with only children who had been diagnosed by their psychiatrist with ADHD ($n = 71$). Among children with co-morbid ADHD: 29.6% were classified as having depressive symptoms only ($n = 21$); 25.4% had only an EF Weakness ($n = 18$); and 45.1% had both depressive symptoms and an EF weakness ($n = 32$). When data were reanalyzed including only children with ADHD, most group differences remained statistically significant. Specifically, after controlling for ADHD, significant group differences remained in the following attributes: length of stay; anxiety; depressive symptoms; trauma-related symptoms; memory functioning; and executive functioning. Thus, the group differences based on Dep-EF status held, suggesting that comorbid ADHD did not account for the Dep-EF effect.

Of note, after controlling for ADHD, the number of diagnoses was no longer statistically significant. Additionally, ANOVA analyses indicated that sex differences between groups emerged when controlling for ADHD ($F(2, 68) = 3.692$, $p = .032$). Amongst children with ADHD, those in the Dep-EF Weakness group were more likely to be female than children in the Dep-Only group (OR = 1.97) or in the EF Weakness-Only group (OR = 6.75).

Discussion

In the current study, approximately half of the pre-adolescent children with severe psychiatric symptomology and depressive symptoms displayed evidence of a co-occurring executive functioning weakness. Children with an executive functioning weakness and depressive symptoms had similar medications and rates of readmission, as well as similar cognitive test performances compared to children with only depressive symptoms or only an EF weakness. However, children with co-occurring depressive symptoms and an executive weakness experienced more severe executive difficulties, poorer memory test performance, higher rates of ADHD, and longer hospitalization stays than children with only EF difficulties or depressive symptoms, respectively. These findings suggest that the co-occurrence of depressive symptoms and EF weaknesses in childhood may be associated with worse outcomes than either elevated depressive symptoms or an executive weakness alone in the presence of severe psychopathology. These results persisted after controlling for co-morbid ADHD diagnosis.

Our results suggest that EF weaknesses may be more pronounced in children with comorbid depressive symptoms and an EF weakness, compared to children with an EF weakness without co-occurring depressive symptoms. Consistent with previous research, our results indicate that comorbid executive weaknesses and depressive symptoms are associated with poorer memory test performance and higher rates of ADHD (Franklin et al. 2010; Willcutt et al. 2005). Given the key role of EF in working memory and attention, this likely reflected the close relationship between memory, attention, and other EF tasks (Pennington and Ozonoff 1996).

Additionally, our study demonstrated that comorbid depressive symptoms and an EF weakness was associated with longer inpatient hospitalizations. This finding has important clinical implications and economic impacts. Depression accounts for 44.1% of child psychiatric hospitalizations (Bardach et al. 2014). Yearly medical expenses for inpatient psychiatric hospitalizations for childhood depression are estimated to have a total cost of $1.33 billion (Bardach et al. 2014). Moreover, a 7-day psychiatric hospitalization costs approximately $15,540 (Bardach et al. 2014). In our sample, youth with comorbid depressive symptoms and an EF weakness had an average stay of 26.17 days. Therefore, this specific subgroup of children likely carried a disproportionally high financial cost. Identification of children with this combined presentation early in their hospitalization may allow for the implementation of adjunctive or more intensive interventions, such as targeted cognitive interventions or supports. Interventions addressing cognitive aspects of childhood psychopathology may contribute to shorter hospitalizations and lower economic costs (Porter et al. 2013).

In contrast to previous research by Lundy et al. (2010), the current study found no association between an EF weakness, depressive symptoms, and slower motor or information processing speeds. Differences between our findings and Lundy et al. (2010) may be due to differences in sample characteristics. Notably, most children in the current study had a diagnosis of ADHD, and all were part of an inpatient group referred for neuropsychological evaluation, whereas Lundy et al.'s (2010) study excluded youth with ADHD from analyses and focused on a non-referred population.

Limitations and Future Research Directions

Our study had several limitations. First, our sample only included children referred for neuropsychological testing in

a psychiatric inpatient setting. It is possible that children who are less likely to be referred for an inpatient consult may have had different cognitive profiles and treatment outcomes than children not referred for consults or children in an outpatient sample. Notably, it is possible that children with mild depressive symptoms—as might be found in community or outpatient samples—might have had different cognitive profiles. Indeed, Vilgis et al. (2015) noted that planning difficulties were observed in severely depressed groups, but not in children with moderate depression. Our sample demonstrated a high degree of comorbid ADHD, trauma, and anxiety symptoms; it is possible that children without co-occurring ADHD, trauma, or anxiety symptoms might have had different outcomes. Also, cognitive profiles may have been impacted by psychiatric medications. Due to sample size constraints we were not able to assess for specific medications, dosages, or combinations of medications, which may have impacted cognitive test performance and other outcomes. Furthermore, children were not administered effort testing during evaluations, which could have impacted the validity of testing results. Moreover, we did not control for grade level, due to lack of availability of this information. Particularly for the youngest children (aged 5) this factor could have impacted performance on tasks (e.g. word fluency) that tend to improve dramatically during the first year of schooling (Fuchs et al. 2004). Finally, the current study relied on a retrospective design focused on a medical record review.

Despite these limitations, our findings provided support for an association between EF and depressive symptoms in pre-adolescent children with severe psychopathology. They also provided support for the clinical utility of recognizing a depression-executive dysfunction phenotype or syndrome, since the combination of executive and depressive symptoms appears associated with poorer cognitive functioning and worse psychiatric outcomes, such as longer hospitalizations and increased costs for hospitalization. For children with the depression-executive dysfunction phenotype and its associated cognitive deficits, research focused on addressing both the cognitive as well as mood symptoms of depression may be helpful in reducing extended lengths of stay in the hospital. Additionally, given that the anterior cingulate cortex and left dorsolateral prefrontal cortex have been linked to performance on measures of EF, and that poor performance on EF measures has been tied to longer hospitalization in youths with depressive symptoms, research focused on cognitive remediation for deficits in these areas may prove helpful for youth with serious psychiatric symptomology (Stuss 2011).

Future studies might also examine whether the increased length of hospitalization is unique to a combination of depressive and EF symptoms or whether increased anxiety and trauma symptoms, which were noted to be higher in groups with depressive symptomology, may also lead to longer hospitalizations. Additionally, future studies might benefit from exploring the effectiveness of cognitive remediation in concert with the treatment of psychiatric symptomology to reduce the length of hospitalization for youth with a depression-executive dysfunction phenotype. Future studies should assess the relationship between neuroanatomical areas implicated in EF and depressive symptoms; this would help improve our understanding of the underlying factors contributing to children with depressive symptoms and executive symptoms displaying poorer cognitive profiles and adverse psychiatric outcomes. Finally, it is important that future investigations compare non-referred, outpatient populations, and children with- and without- ADHD to children with more severe symptomology to determine the generalizability of depression-executive dysfunction syndrome to children with less severe psychopathology.

In sum, the current study examined the unique and combined effects of executive weakness and depressive symptoms among preadolescents (ages 6 to 12) who underwent a neuropsychological evaluation during a psychiatric hospitalization. The current study also evaluated the effects of depressive symptoms with a co-occurring EF Weakness on psychiatric outcomes. Close to half of children with depressive symptoms had a co-occurring executive weakness. Children with both depressive symptoms and an executive weakness had a greater likelihood of having comorbid Attention-Deficit/Hyperactivity Disorder (ADHD), poorer cognitive test performance on measures of verbal memory, and longer hospitalizations than children with depressive symptoms or an executive weakness alone. Results suggest the clinical utility of a depression-executive dysfunction phenotype since it may help identify those with depressive symptoms who are at risk for longer stays in the hospital. Longitudinal studies investigating whether EF difficulties are linked to the etiology of depressive symptoms may provide diagnostic utility in pediatric populations. This research is vitally important because the adverse outcomes associated with the depression-executive dysfunction phenotype are associated with an increased cost and a reduced number of patients served (Bardach et al. 2014).

Author Contributions E.B.W.: conceptualized and designed the study, executed statistical analyses, and drafted the initial manuscript. B.C.K.: conceptualized and designed the study, executed statistical analyses, drafted several parts of the manuscript, critically reviewed the manuscript, and approved the final version. J.S., N.E.C., and G.C.: consulted about the study, helped draft and revise the manuscript, critically reviewed the manuscript, and approved the final version. K.M.: critically reviewed the manuscript and approved the final version. K.A.H.: conceptualized and designed the study, critically reviewed the manuscript, and approved the final version.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethics Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. For this type of study formal consent is not required. Please see the methods section for further details of informed consent procedures.

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