OXFORD
UNIVERSITY PRESS

Archives of Clinical Neuropsychology 31 (2016) 934–943

Archives of CLINICAL NEUROPSYCHOLOGY

Verbal Memory Abilities in Severe Childhood Psychiatric Disorders and the Influence of Attention and Executive Functions

Brian C. Kavanaugh[1,2,*], Charles E. Gaudet[3], Jennifer A. Dupont-Frechette[3], Perrin P. Tellock[4], Isolde D. Maher[5], Lauren D. Haisley[6], Karen A. Holler[1,2]

[1]*E. P. Bradley Hospital, East Providence, RI, USA*
[2]*Alpert Medical School of Brown University, East Providence, RI, USA*
[3]*University of Rhode Island, Kingston, RI, USA*
[4]*Antioch University New England, Keene, NH, USA*
[5]*Mount Holyoke College, South Hadley, MA, USA*
[6]*University of Connecticut, Storrs, CT, USA*

*Corresponding author at: Emma Pendleton Bradley Hospital, 1011 Veterans Memorial Parkway, East Providence, RI 02915, USA, Tel.: +1-401-432-1359.
E-mail address: brian_kavanaugh@brown.edu (B. Kavanaugh).

Accepted 24 March 2016

Abstract

Despite prior adult research regarding the influence of executive functions on memory performance, there has been inconsistent prior research on the role of executive functions on memory performance in children, particularly those children with severe psychiatric disorders. A medical chart review was conducted for 76 children (ages 6–12 years) who received a neuropsychological evaluation during children's psychiatric inpatient program hospitalization. A series of hierarchical regression analyses investigated the role of attention/executive and non-executive functions in verbal memory performance (immediate recall, delayed recall, and delayed recognition). Demographic and verbal measures were entered into blocks 1 and 2 for all analyses, followed by attention and executive functions (i.e., attention span, sustained attention, verbal fluency, cognitive flexibility, inhibitory control, and planning/organization). Nearly 15% of the participants displayed memory impairment. Results of regression analyses indicated attention/executive dysfunction severity predicted overall memory performance. Attention span predicted performance on all three memory conditions. Planning/organization accounted for unique variance in immediate recall condition while inhibitory control accounted for unique variance in delayed recall condition. These results indicate that verbal memory problems frequently occur in severe childhood psychiatric disorders. Further, planning/organization deficits may influence immediate recall, while inhibitory control deficits may influence delayed recall. Alternatively, delayed recognition memory may be the most resistant to the negative influence of executive deficits on verbal memory performance in childhood psychiatric disorders.

Keywords: Assessment; Learning and memory; Children and behavioral disorders; Executive functions

Memory is a complex neurocognitive domain that involves the encoding, retaining, and retrieving of information (Schaefer & Hebben, 2014). Due to the complexity of the memory process, effective memory is highly dependent on other neurocognitive domains such as language, attention, processing speed, and executive functions (Baron, 2004; Lezak et al., 2004). Particularly in childhood non-neurologic settings, the effective clinician must consider the integrity of other neurocognitive functions as potential contributors to poor memory performance (Baron, 2004; Lezak et al., 2004). Poor memory performance on standardized neuropsychological measures has been previously identified in childhood psychiatric disorders such as bipolar disorder (Dickstein et al., 2004; Glahn et al., 2005; McClure et al., 2005; Udal, Oygarden, Egeland, Malt, & Groholt, 2012), ADHD (Andersen, Hovik, Skogli, Egeland, & Oie, 2013; Henin et al., 2007; Udal et al., 2012), depressive disorders (Brooks, Iverson, Sherman, & Roberge, 2010; Gunther, Holkamp, Jolles, Herpertz-Dahlmann, & Konrad, 2004; Lauer et al., 1994), psychosis (Udal et al., 2012), and psychiatric comorbidity (Frost, Moffitt, & McGee, 1989).

Such studies have evaluated memory with verbal list learning (Andersen et al., 2013; Brooks et al., 2010; Frost et al., 1989; Glahn et al., 2005; Gunther et al., 2004; Henin et al., 2007; Lauer et al., 1994; McClure et al., 2005; Udal et al., 2012), and

doi:10.1093/arclin/acw020 Advance Access publication on 28 April 2016

spatial/figure recognition measures (Brooks et al., 2010; Dickstein et al., 2004), with only one study utilizing a story-format memory measure (McClure et al., 2005). In McClure and colleagues (2005) study, poor story memory performance was identified within the bipolar group in immediate and delayed recall (no administered recognition format). Prior research has provided limited information regarding the specific memory stage that may be impaired in childhood psychiatric disorders (e.g., encoding or retrieval). For example, in one study depression/anxiety disorders were associated with poor delayed recall and recognition, but not immediate recall nor learning curve (Gunther et al., 2004), while in another study depression was associated with poor immediate recall and not delayed recall or learning curve (Lauer et al., 1994). Childhood psychiatric disorders appear to be associated with a non-specific pattern of lowered memory performance, although research on verbal memory for semantically complex information remains limited.

Childhood psychiatric disorders also frequently display associated deficits in executive functions, a collection of "top-down" control and self-regulatory processes required to obtain goals and objectives (Barkley, 2012; Diamond, 2013). Many of the same studies that identified poor memory functioning in these disorders also identified deficits in executive functions, or the presence of executive dysfunction (Andersen et al., 2013; Brooks et al., 2010; Dickstein et al., 2004; Henin et al., 2007). Given the inherent executive dysfunction in childhood psychiatric disorders (Hale & Fitzer, 2015), it could be hypothesized that poor memory in childhood psychiatric disorders may be largely influenced by executive dysfunction. While two studies evaluated group differences of the presence/absence of ADHD diagnosis/symptoms (Andersen et al., 2013; Henin et al., 2007), none of the studies evaluated the potential influence of executive functions on memory performance. In adult clinical neuropsychology samples, memory and executive abilities have a high degree of clinical overlap (e.g., sequencing/working memory; Duff, Schoenberg, Scott, & Adams, 2005), with poor verbal memory performance identified in patients with executive dysfunction (Hill, Alosco, Bauer, & Tremont, 2012; Tremont, Halpert, Javorsky, & Stern, 2000). Executive measures also account for a large proportion of memory performance variance in adult samples (e.g., complex visual sequencing and set shifting; Hill et al., 2012; Temple, Davis, Silverman, & Tremont, 2006). The pediatric literature remains more limited. While attention/executive functions did not contribute to verbal memory performance in a large, mixed pediatric sample (Jordan, Tyner, & Heaton, 2013), attention/executive functions (including planning, abstraction, and mental tracking) predicted verbal and visual memory in a pediatric sample of temporal lobe epilepsy (Rzezak, Guimaraes, Fuentes, Geurreiro, & Valente, 2012). In this sample, the severity of executive dysfunction was additionally associated with lowered memory performance.

Given the inconsistent research on the neurocognitive contributors to poor memory performance in children, this study sought to examine the verbal memory abilities (i.e., story memory) in a sample of children in an admission to inpatient psychiatric treatment program. This sample is defined as children with severe psychiatric disorders, given the severity of their psychiatric presentation requires the most intensive psychiatric treatment (i.e., inpatient care). This is instead of the more pejorative terms previously used to describe similar groups of children requiring hospitalization (e.g., psychiatrically disturbed inpatients). It was hypothesized that a large portion of the sample would display poor memory abilities (indicated by a high degree of impaired scores) and that memory performance would be predicted by a combination of attention/executive and non-executive (i.e., verbal) domains.

Method

Participants

IRB approval was obtained to conduct this medical chart review study. Two-hundred and thirty-eight children consecutively referred for a neuropsychological evaluation at a children's inpatient psychiatric program within a medical school-affiliated children's psychiatric hospital were considered for inclusion in the present study. Participants were generally referred for neuropsychological evaluation to characterize neurocognitive functioning and guide treatment planning. The program admits children ages 3–12, although the majority of children referred for neuropsychological evaluation are 6–12 years of age. The inclusion criteria for the present study were 6–12 years of age at the time of the neuropsychological evaluation, sufficient information available in hospital medical records to extract key variables, a diagnosis of at least one psychiatric disorder by a hospital psychiatrist according to DSM-IV-TR or later DSM-5 criteria following psychiatric evaluation as part of the hospitalization (American Psychiatric Association, 2000, 2013), and completion of memory, verbal, and attention/executive measures utilized in the present study. The WRAML-2 Story Memory is the primary verbal memory measure administered in the brief neuropsychological battery and thus the only memory measure available for the present study.

Seventy-six children met inclusion criteria (out of total 238, primarily due to low sample size of the CPT-II and WCST) and were included in this neuropsychology-referred group. All 76 children completed every memory, verbal and attention/executive tasks. From this total group (NP Group; $n = 76$), a 1:1 age- and sex-matched control group was obtained from a sample of children who participated in the inpatient program from 2010 to 2015 but did not receive a neuropsychological evaluation ($n = 153$). This age/sex matching from the sample without a neuropsychological evaluation resulted in a No-NP Group ($n = 75$).

Neuropsychological evaluation within the inpatient program is typically initiated following the initial psychiatric evaluation and conducted over several sessions and/or days depending on the functioning of the child. A standard neuropsychological battery is administered by the clinical neuropsychologist, psychometrician, and/or graduate-level neuropsychology trainee. Age, sex, race, history of legal involvement, use of public insurance, and childhood maltreatment history were used to provide demographic information on the sample. Psychiatric variables included hospitalization length of stay (LOS; in days), status as new admission or re-admission to the hospital, the mean number of diagnoses, rate of diagnostic comorbidity, self-reported anxiety (Multidimensional Anxiety Scale for Children [MASC/MASC-2])/depression (Children's Depression Inventory [CDI/CDI-2]) symptoms and the presence of specific psychiatric and neurodevelopmental disorders diagnosed during hospitalization. Mood disorders were categorized into Depressive Disorders (Major Depressive Disorder, Dysthymic Disorder, and Depressive Disorder Not Otherwise Specified), Bipolar Disorder, and (other) Mood Disorders (Mood Disorder Not Otherwise Specified and Disruptive Mood Dysregulation Disorder).

Information on medication status at the time of the neuropsychological evaluation was not available; however, medication status at the time of admission was utilized in the present study. The standard practice is for the children to take their medication as usual during their neuropsychological evaluation. Medications at intake were classified into mood stabilizers, anxiolytics, antipsychotics/atypical antipsychotics, anti-depressants (SSRIs and others [e.g., bupropion]), and stimulants/non-stimulants (stimulants [e.g., methylphenidate] and non-stimulants [e.g., guanfacine]). DCYF involvement and maltreatment history were only available for the NP Group. Discharge diagnoses were not available for the No-NP Group ($n = 75$), while they were available for the NP Group ($n = 76$). Therefore, No-NP/NP analyses utilized the intake diagnoses, while descriptive data on discharge diagnoses for NP Group are also provided.

Neuropsychological Measures

Wide range assessment of memory and learning-second edition. The Wide Range Assessment of Memory and Learning-Second Edition (WRAML-2; Sheslow & Adams, 2003) is a standardized test of memory functioning. Verbal memory abilities were assessed in the present study with the subtest Story Memory (i.e., Immediate Recall), Story Memory Delayed Recall (20–30 min after administration), and Story Memory Recognition (i.e., Delayed Recognition). Verbal attention span was assessed with Sentence Memory.

Wechsler scales. Intelligence was assessed with the Wechsler Abbreviated Scale of Intelligence (WASI-I/II; Wechsler, 1999, 2011) or Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV; Wechsler, 2003). Vocabulary and Similarities subtests from WASI/WASI-II/WISC-IV were used in the present study to assess verbal reasoning abilities. Block Design and Matrix Reasoning were used to assess construction/perception in one follow-up analysis.

COWAT-FAS. The Controlled Oral Word Association Test (COWAT) is a task of verbal fluency (Baron, 2004; Strauss et al., 2006). The phonemic condition, FAS, asks the participant to produce words starting with letters F, A, S for 1 min per letter. The current study utilized COWAT-FAS to assess verbal fluency.

Trail Making Test-B. The Trail Making Test-B is a task of attention, speed, and cognitive flexibility (TMT-B; Baron, 2004; Strauss et al., 2006). TMT-B was used in the present study to assess cognitive flexibility.

Stroop Color and Word Test-Children's Version. The Stroop Color and Word Test-Children's Version (Golden, Freshwater, & Golden, 2003) is a commonly used measure to assess inhibitory control in children (Baron, 2004; Strauss et al., 2006). The Color-Word condition (Stroop C-W) assessed response inhibition in the current study.

Wisconsin Card-Sorting Test. The Wisconsin Card-Sorting Test (WCST; Heaton, Chelune, Talley, Kay, & Curtiss, 1993) is a test of executive function that assesses skills in abstraction, shifting and maintaining focus, goal orientation, and interference control (Baron, 2004; Strauss et al., 2006). The WCST-64 and WCST-128 are included in the current study. The standard neuropsychological battery included WCST-64 (manual administration) until early 2014, at which time the WCST-128 (computerized administration) became part of the standard battery. Therefore, a small subsample of the current study were administered the WCST-128 ($n = 24$). Analysis of variance between WCST-64 and WCST-128 on perseverative errors showed no significant group differences ($F(1,74) = 2.148, p = .147$). Perseverative Errors (WCST PE) standardized score (T-score) for WCST-64 or WCST-128 was utilized in the present study to assess cognitive flexibility.

Conners' Continuous Performance Test. The Conners' Continuous Performance Test (CPT-II; Conners, 2000) is a measure of vigilance, attentional control and inhibition (Baron, 2004; Strauss et al., 2006). The Variability score was used in the present study as a gross estimate of overall sustained attention (Baron, 2004).

Rey Complex Figure Test-Copy Condition. The Rey Complex Figure Test (RCFT)-Copy Condition is a drawing task with constructional, perceptual, spatial, and executive components (Baron, 2004; Strauss et al., 2006). As part of the clinical neuropsychological battery, the RCFT-Copy condition is scored using the standard Taylor Scoring Criteria (Kolb & Whishaw, 1990). While the RCFT is a constructional task (Baron, 2004), it contains inherent perceptual/constructional and executive demands (Baron, 2004; Kavanaugh & Holler, 2015). The RCFT-Copy Condition was used in the present study as a task of organization/planning.

Beery-Buktenica Developmental Test of Visual-Motor Integration. The Beery-Buktenica Developmental Test of Visual-Motor Integration-Fifth Edition is a task of visual-motor integration (VMI; Beery & Beery, 2004). The VMI was used in the present study as a measure of constructional abilities in one follow-up analysis.

Statistical Methodology

Analyses of variance (ANOVAs) and chi-squared analyses compared the NP Group with the No-NP Group on relevant variables. Subsequent analyses only included the NP Group. Descriptive data (mean and standard deviation [*SD*]) were obtained for each neuropsychological measure. The presence of impairment was calculated for each score, defined as 1.5 SDs below the mean. Memory impairment was defined as 2+ impaired memory scores (Beauchamp et al., 2015). Differences between memory scores were assessed with paired *t*-tests. Point-biserial analyses assessed associations between potential confounding variables and memory performance. An attention/executive dysfunction severity score (0–7) was calculated by summing each child's total number of impaired range scores (1.5 *SD* below mean) derived from attention (CPT-II Variability, Sentence Memory) and executive (WCST, COWAT-FAS, TMT, Stroop, RCFT) measures. A memory composite score was calculated as the mean of the three memory measures (Immediate Recall + Delayed Recall + Delayed Recognition/3).

A series of multiple regression analyses examined the predictors of memory performance. First, the memory composite score served as the dependent variable, with demographic (age, sex, and number of diagnoses), verbal (vocabulary and similarities), and the attention/executive dysfunction severity score entered as independent variables. Next, individual levels of memory were examined. For each regression analysis, demographic (age, sex, and number of diagnoses), verbal (vocabulary and similarities), and the seven attention/executive scores (i.e., CPT-II Variability, Sentence Memory, WCST, COWAT-FAS, TMT, Stroop, and RCFT) were entered as the independent variables, with the respective memory score as the dependent variable (i.e., Immediate Recall, Delayed Recall, and Delayed Recognition).

Two supplemental regression analyses were conducted. To address potential demographic factors (which were not addressed in primary analyses due to inconsistent data that resulted in lowered sample sizes), race, use of public insurance, and legal involvement were entered with original demographic variables, followed by verbal variables, and the attention/executive dysfunction severity score. The memory composite score was entered as the dependent variable. Any analyses in which the RCFT showed a significant association to the memory-dependent variable would be replicated while also loading Block Design, Matrix Reasoning, and Beery VMI (along with RCFT) into Step 3. This was done to address whether any findings were due to the perceptual/constructional demands of the RCFT. Myers (1990) suggests that Variance Inflation Factor values >10 would indicate collinearity. Unless otherwise noted, multicollinearity (as assessed with VIF) was not detected in regression analyses.

Results

Group Differences and Descriptive Statistics

The NP Group and No-NP Group did not differ significantly on the majority of variables. However, the NP Group displayed longer length of stay, higher prevalence of behavioral disorders, and lower prevalence of depressive disorders and autism spectrum disorders (although this finding is interpreted cautiously due to low prevalence of ASD in either group). Descriptive data on maltreatment, DCYF, and discharge diagnoses for the NP Group are also provided. Results are provided in Table 1.

Mean (*SD*) values and rates of impairment (1.5 *SD* below normative mean) are provided for each neuropsychological measure in Table 2. FSIQ is reported as a standard score, CPT-II, Stroop C-W, and WCST Perseverative Errors are reported as *t*-scores, COWAT-FAS, TMT-B, and RCFT scores are reported as *z*-scores, and remaining scores are reported as scaled scores. Of the sample, 14.5% displayed 2+ impaired memory scores; and 34.2% of the sample displayed impaired Stroop C-W score and RCFT-Copy, while only 5.3% of the sample displayed impaired Sentence Memory. The presence of intake medications, including stimulant/non-stimulant, anti-depressant, mood stabilizer, or atypical/typical antipsychotic was not associated with memory

Table 1. Demographic and psychiatric information for neuropsychology-referred and not neuropsychology-referred groups

	n	NP Group ($n = 76$)	No-NP Group ($n = 75$)	F/X^2
Demographic				
Age	151	122.47 (19.93)	122.56 (19.38)	.001
% Male	151	70%	71%	.016
% Caucasian	126	58%	64%	.567
% Public insurance	144	63%	70%	.681
Maltreatment	74	59.5%	-	-
DCYF	69	50.7%	-	-
Psychiatric				
Readmission	149	32%	37%	.394
CDI/CDI-2	140	63.65 (14.04)	65.57 (14.27)	.645
MASC/MASC-2	140	54.29 (10.67)	55.22 (13.26)	.207
Length of stay	147	21.07 (16.67)	13.45 (11.86)	**10.24****
Intake diagnoses				
No. of Dx	149	2.08 (0.99)	2.09 (.92)	.006
ADHD	150	59%	52%	.674
Depression	149	15%	35%	**7.825****
Bipolar	149	8%	3%	2.171
Other mood	151	53%	40%	2.422
Anxiety	149	43%	49%	.556
Behavioral	149	29%	12%	**6.214***
Adjustment	149	3%	5%	.667
Psychotic	149	5%	1%	1.904
PDD/ASD	149	0%	5%	**4.056***
Learning Disorder	149	1%	8%	3.678
Language Disorder	149	3%	0%	2.055
Tic Disorder	149	0%	1%	.993
Discharge Diagnoses				
No. of Dx	76	2.43 (0.91)	–	–
% Comorbidity	76	81.6%	–	–
ADHD	76	68.4%	–	–
Depression	76	17.1%	–	–
Bipolar	76	3.9%	–	–
Other mood	76	47.4%	–	–
Anxiety	76	53.9%	–	–
Behavioral	76	15.8%	–	–
Adjustment	76	13.2%	–	–
Psychotic	76	1.3%	–	–
PDD/ASD	76	2.6%	–	–
Learning disorder	76	3.9%	–	–
Language disorder	76	6.6%	–	–
Tic disorder	76	2.6%	–	–
Intake medications				
Stim/non-stim	149	45%	52%	.818
Anti-depressant	149	24%	36%	2.409
Antipsychotic	149	24%	17%	1.105
Mood stabilizer	149	11%	8%	.346
Anxiolytic	149	0%	3%	2.00

"*Note:* * $p < .05$; ** $p < .01$; *** $p < .001$."

performance. Discharge diagnosis of ADHD was also not associated with memory performance. Results are provided in Table 3. Paired t-tests indicated that Immediate Recall and Delayed Recall did not display significant differences from one another ($t = .710$; $p = .480$), while Delayed Recognition was significantly higher than Immediate Recall ($t = -3.048$; $p = .003$) and Delayed Recall ($t = -3.195$; $p = .002$).

Regression Analyses

A multiple regression was run to predict memory composite score from the attention/executive dysfunction severity score after controlling for age, sex, number of diagnoses, as well as vocabulary and similarities performance. The overall model was

Table 2. Mean, standard deviation (*SD*), and rates of impaired scores (<1.5 *SD* below normative mean) for neuropsychological measures

	n	Mean (*SD*)	% Impaired
Overall intelligence			
FSIQ	76	94.66 (13.89)	10.5%
Memory			
Immediate recall	76	8.33 (2.99)	14.5%
Delayed recall	76	8.18 (2.94)	19.7%
Delayed recognition	76	9.12 (3.03)	15.8%
2+ Memory impairment scores		–	14.5%
Verbal intelligence			
Similarities	76	9.58 (2.78)	6.6%
Vocabulary	76	9.12 (2.92)	7.9%
Attention span/sustained attention			
Sentence memory	76	9.29 (2.72)	5.3%
CPT-II variability	76	57.77 (9.36)	23.7%
Executive functions			
COWAT-FAS	76	−0.31 (0.96)	10.5%
TMT-B	76	−0.43 (1.10)	17.1%
Stroop C-W	76	38.42 (11.44)	34.2%
RCFT-Copy	76	−0.90 (1.26)	34.2%
WCST perseverative errors	76	52.32 (15.20)	13.2%

Table 3. Bivariate correlations between medications/ADHD and memory performance (*r* values)

	Immediate recall	Delayed recall	Delayed recognition
Stimulant/non-stimulant	0.018	0.058	0.008
Anti-depressant	0.120	0.004	0.107
Mood stabilizer	−0.077	−0.054	−0.220
Anti-psychotic	−0.151	−0.220	−0.183
ADHD diagnosis	−0.118	−0.084	0.053

"*Note:* None significant $p < .05$."

Table 4. Multiple regression analysis of the predictors of memory composite score

	R^2 change	β	*p*
Step 1	.090		.085
Age		−0.096	.405
Sex		**−0.233**	**.047**
# of Diagnoses		−0.194	.097
Step 2	.129		.005
Vocabulary		0.171	.206
Similarities		0.251	.071
Step 3	.110		.001
Atten/executive dysfx severity		**−0.367**	**–**

"*Note:* $n = 74$. *p* reflects the *F* change *p* value."

statistically significant, $F(6,67) = 5.480$, $p = <.001$, $R^2 = .329$. Sex ($p = .047$; $\beta = -0.233$) and the attention/executive dysfunction severity score ($p = .001$; $\beta = -0.367$; 11% of variance) independently predicted memory composite performance. Results are provided in Table 4.

A multiple regression was run to predict immediate recall from the specific attention/executive scores after controlling for age, sex, number of diagnoses, as well as vocabulary and similarities performance. The overall model was statistically significant, $F(12,61) = 4.009$, $p < .001$, $R^2 = .441$. Sex ($p = .044$; $\beta = -0.235$). Similarities ($p = .015$; $\beta = 0.336$), Sentence Memory ($p = .004$; $\beta = 0.320$), and RCFT ($p = .039$; $\beta = 0.229$) independently predicted immediate recall performance. A multiple regression was run to predict delayed recall from the specific attention/executive scores after controlling for age, sex, number of diagnoses, as well as vocabulary and similarities performance. The overall model was statistically significant, $F(12,61) = 3.486$, $p = .001$, $R^2 = .407$. Sex ($p = .043$; $\beta = -0.329$), Sentence Memory ($p = .001$; $\beta = 0.377$), and Stroop C-W

Table 5. Multiple regression analysis of the predictors of individual memory scores

	Immediate recall			Delayed recall			Delayed recognition		
	Model R^2	β	p	Model R^2	β	p	Model R^2	β	p
Step 1	.100		.060	.085		.100	.051		.298
Age		−0.089	.439		−0.032	.784		−0.138	.243
Sex		−0.235	**.044**		**−0.329**	**.043**		−0.158	.186
No. of diagnoses		−0.225	.053		−0.202	.086		−0.098	.409
Step 2	.147		.002	.075		.055	.115		.012
Vocabulary		0.101	.447		0.232	.099		0.130	.349
Similarities		**0.336**	**.015**		0.076	.594		0.265	.066
Step 3	.194		.008	.247		.002	.276		.001
Sentence memory		**0.320**	**.004**		**0.377**	**.001**		**0.520**	**<.001**
CPT-II variability		−0.222	.063		−0.157	.199		0.157	.186
WCST-PE		0.008	.940		0.016	.891		0.086	.436
COWAT-FAS		0.022	.844		−0.066	.566		0.019	.860
TMT B		0.041	.725		0.039	.748		0.127	.280
Stroop C-W		0.033	.775		**0.270**	**.024**		0.161	.161
RCFT		**0.229**	**.039**		0.126	.264		0.150	.172

"*Note:* $n = 74$. p reflects the F change p value."

Table 6. Multiple regression analysis of the predictors of memory composite score with demographic variables

	Model R^2	β	p
Step 1	.192		.133
Age		−0.025	.862
Sex		−0.137	.331
No. of diagnoses		−0.075	.635
DCYF		0.010	.953
Public insurance		−0.229	.167
Caucasian status		0.283	.050
Step 2	.090		.083
Vocabulary		0.154	.370
Similarities		0.251	.130
Step 3	.077		.032
Atten/executive Dysfx severity		**−0.310**	–

"*Note:* $n = 51$. p reflects the F change p value."

($p = .024$; $\beta = 0.270$) independently predicted delayed recall performance. A multiple regression was run to predict delayed recognition from the specific attention/executive scores after controlling for age, sex, number of diagnoses, as well as vocabulary and similarities performance. The overall model was statistically significant, $F(12,61) = 4.026$, $p < .001$, $R^2 = .442$. Sentence Memory ($p = <.001$; $\beta = 0.520$) independently predicted delayed recall performance. Across the three memory conditions, attention/executive scores accounted for 19.4–27.6% of unique variance above that from demographic and verbal variables. Results are provided in Table 5. All analyses had VIF scores ≤ 2.

Supplemental Analyses

A follow-up multiple regression was run to predict memory composite score from the attention/executive dysfunction severity score after controlling for age, sex, number of diagnoses, DCYF involvement, percent identified as white/Caucasian, use of public insurance, as well as vocabulary and similarities performance. The overall model was statistically significant, $F(9,41) = 2.560$, $p = .019$, $R^2 = .360$. Only the attention/executive dysfunction severity score ($p = .032$; $\beta = -0.310$) independently predicted memory composite performance. Results are provided in Table 6.

RCFT was associated with immediate recall performance. Therefore, a follow-up multiple regression was run to predict immediate recall from the RCFT after controlling for constructional/perceptual demands. Age, sex, number of diagnoses, vocabulary and similarities were entered as prior regression analyses. Step 3 included Block Design, Matrix Reasoning, Beery VMI, and RCFT. The overall model was statistically significance, $F(9,63) = 3.483$, $p = .002$, $R^2 = .332$. Sex ($p = .045$; $\beta = -0.236$),

Table 7. Multiple regression analysis of the role of RCFT in immediate recall when controlling for construction/perception

	Model R^2	β	p
Step 1	.100		.062
Age		−0.090	.433
Sex		**−0.236**	**.045**
No. of diagnoses		−0.223	.057
Step 2	.148		.002
Vocabulary		0.103	.439
Similarities		**0.336**	**.016**
Step 3	.084		.106
Block design		−0.116	.426
Matrix reasoning		0.000	.998
Beery VMI		0.157	.233
RCFT		**0.257**	**.041**

"*Note: n* = 73. *p* reflects the F change *p* value."

similarities ($p = .016$; $\beta = 0.336$) and RCFT ($p = .041$; $\beta = 0.257$) independently predicted immediate recall. No other constructional/perceptual measures had statistically significant associations with immediate recall. Results are provided in Table 7.

Discussion

The present study evaluated the verbal memory abilities of 76 children within a psychiatric inpatient sample. Our hypotheses were generally supported: a large portion of children displayed poor verbal memory abilities and memory performance in the sample was significantly influenced by attention/executive functions, particularly inhibitory control and planning/organization. Further, there were minimal differences between this sample and a non-referred inpatient control sample (after age/sex matching), suggesting results may be generalizable to the entire inpatient setting.

Nearly 15% of the children with severe psychiatric disorders displayed evidence of verbal memory impairment (i.e., 2+ scores <1.5 *SDs* below normative mean), consistent with prior research on poor verbal memory abilities in childhood psychiatric disorders (Andersen et al., 2013; Brooks et al., 2010; Frost et al., 1989; Glahn et al., 2005; Gunther et al., 2004; Henin et al., 2007; Lauer et al., 1994; McClure et al., 2005; Udal et al., 2012). Memory performance was similarly distributed across memory stages, although delayed recognition was significantly stronger than both immediate and delayed recall. This memory pattern, specifically poor encoding and retrieval with stronger recognition performance, suggests that the children are not experiencing an overt dementing process. Rather, this is a pattern more often observed in adults with prefrontal cortical lesions (Blumenfeld & Ranganath, 2007) and depression (O'Hara, Coman, & Butters, 2006). Such conditions are associated with poor performance on trials that have high executive demands, yet stronger memory performance is observed when provided increased structure and assistance in the retrieval processes (Blumenfeld & Ranganath, 2007; O'Hara et al., 2006). While investigation in children remains more limited, current results suggest children with psychiatric disorders may display a relative strength in delayed recognition compared with weaker recall abilities.

Multiple neurocognitive domains, including verbal intellectual abilities, auditory attention span, inhibitory control, and planning/organization were significantly associated with memory performance. Verbal intellectual abilities accounted for 8–15% of memory variance, consistent with the hypothesis that successful encoding of verbal information is dependent on verbal abilities (Baron, 2004). Attention/executive dysfunction severity accounted for 11% of overall memory performance, while performance on specific attention/executive measures accounted for 19–28% of variance in individual memory scores. Cognitive flexibility, verbal fluency, and sustained attention did not independently account for any variance in memory performance. Attention span predicted performance across the three memory conditions, although this is likely related to the association between this measure and the memory measures (WRAML-2 measures). Planning/organization predicted immediate recall, while inhibitory control predicted delayed recall. Only attention span predicted delayed recognition. Results suggest that attention and executive functions have a large influence (up to 28% of variance) on subsequent verbal memory performance in children with severe psychiatric disorders. Results are consistent with one prior pediatric study on a sample of children with temporal lobe epilepsy (Rzezak et al., 2012), including the influence of overall executive dysfunction and the role of specific executive functions in memory performance. However, it is inconsistent with another pediatric study (Jordan, Tyner, & Heaton, 2013), suggesting that further research is needed.

Distinct attention and executive functions may have a differential effect on specific stages of the verbal memory process. Current results suggest that successfully encoding syntactically complex information is dependent on the ability to attend to incoming information (i.e., attention span) and effectively organize the complex information in a manner that maximizes storage (i.e., planning/organization). Free recall of that information after a prolonged delay also appears dependent on attention span, as well as dependent one's ability to store initially presented information and inhibit the distractible influence of information/stimuli presented in between trials and/or to provide responses that are not impulsive or poorly controlled (i.e., inhibitory control). Generally, one's ability to recall learned information appears dependent on multiple attention and executive functions. While the attention/executive step of the regression accounted for 28% of delayed recognition variance, only attention span independently predicted performance. Beyond attention span (which is likely the least executive measure utilized), results may suggest that this memory trial has lower executive demands and can mitigate the influence of executive deficits. A potential, speculative explanation of the attention span finding (beyond just because they are highly similar measures) is that delayed recognition emphasizes details and incorrect answers may be provided due to a lack of attention to the specific components of the question.

From a neuroanatomical perspective, psychiatric disorders are subserved by neural regions such as the limbic and cortical structures (e.g., prefrontal cortex, temporal lobes; Barisa, 2014; Boada, Kirk, & Fischer, 2014). Similarly, memory is subserved by limbic, temporal as well as prefrontal regions (Bauer, 2014; Blumenfeld, 2010; Blumenfeld & Ranganath, 2007) while executive functions are subserved by limbic and prefrontal regions (Bauer, 2014). Thus, it is understandable that children with known psychiatric and executive dysfunction will also display at least some evidence of suboptimal memory performance, potentially due to underlying limbic, prefrontal as well as temporal lobe involvement. Current results are not unexpected and are consistent with the prior notion that memory and executive functions are highly intertwined and overlapping neurocognitive functions. In the psychiatric inpatient setting, executive dysfunction is highly prevalent and such dysfunction may potentially influence performance on verbal memory measures. It is possible that this effect is at least partially mitigated by the delayed recognition format, although generally this effect was found across conditions. The implementation of overt behavioral interventions (e.g., attentional prompts and reminders to ensure maximal attention, taking a break if suboptimal attention is detected) during memory task administration could help mitigate such an influence. However, the influence of executive functions should always be considered when interpreting memory performance, particularly with regard to a child's hypothesized maximal ability as well as his or her memory ability in the context of ongoing attention/executive dysfunction.

There are inherent limitations to the present study, primarily due to the reliance on retrospective chart review. While a non-referred control sample was compared on psychiatric and demographic variables, participants in the study were referred for neuropsychological evaluation during their hospitalization by their psychiatric team and therefore current findings may not generalize to the entire inpatient population. Further, given the severity of this population and high rate of psychiatric disorders, findings may not easily translate to typical outpatient neuropsychological settings. There are many different types of memory, and the present study only evaluated episodic, story-format memory. Ideally, future studies will evaluate various formats of verbal memory, visual memory, and other executively involved memory processes such as prospective memory. Additionally, medication information at the time of the evaluation was not available, limiting the generalizability of our findings. Medication at intake likely only partially addressed the role of medication on testing performance. Finally, while our sample size was not overtly small ($n = 76$), future studies will hopefully confirm current findings in larger sized studies.

References

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders (*4th ed. text rev.). Washington, DC: Author.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders*. Washington, DC: Author.

Andersen, P. N., Hovik, K. T., Skogli, E. W., Egeland, J., & Oie, M. (2013). Symptoms of ADHD in children with high-functioning autism are related to impaired verbal working memory and verbal delayed recall. *PLoS ONE*, *8*, e64842.

Barisa, M. T. (2014). Mood disorders: Depression, mania, and anxiety. In K. J. Stucky, M. W. Kirkwood, & J. Donders (Eds.), *Neuropsychology study guide & board review* (pp. 519–543). New York: Oxford University Press.

Barkley, R. A. (2012). *Executive functions: What they are, how they work, and why they evolved*. New York: The Guilford Press.

Baron, I. S. (2004). *Neuropsychological evaluation of the child*. New York, NY: Oxford University Press.

Bauer, R. M. (2014). Functional neuroanatomy and essential neuropharmacology. In K. J. Stucky, M. W. Kirkwood, & J. Donders (Eds.), *Neuropsychology study guide & board review* (pp. 26–49). New York: Oxford University Press.

Beauchamp, M. H., Brooks, B. L., Barrowman, N., Aglipay, M., Keightley, M., Anderson, P., et al. (2015). Empirical derivation and validation of a clinical case definition for neuropsychological impairment in children and adolescents. *Journal of the International Neuropsychological Society*, *21*, 596–609.

Beery, K., & Beery, N. (2004). *Beery-Buktenica developmental test of visual motor integration manual*. Minneapolis, MN: NCS Pearson.

Blumenfeld, H. (2010). *Neuroanatomy through clinical cases* (2nd ed.). Sunderland, MA: Sinauer Associates.

Blumenfeld, R. S., & Ranganath, C. (2007). Prefrontal cortex and long-term memory encoding: An integrative review of findings from neuropsychology and neuroimaging. *Neuroscientist*, *13*, 280–291.

Boada, R., Kirk, J. W., & Fischer, M. (2014). Attention-deficit/hyperactivity disorder. In K. J. Stucky, M. W. Kirkwood, & J. Donders (Eds.), *Neuropsychology study guide & board review* (pp. 202–216). New York: Oxford University Press.

Brooks, B. L., Iverson, G. L., Sherman, E. M., & Roberge, M.-C. (2010). Identifying cognitive problems in children and adolescents with depression using computerized neuropsychological testing. *Applied Neuropsychology*, *17*, 37–43.

Conners, C. K. (2000). *CPT-II: Continuous performance test II: Computer program for windows technical guide and software manual*. Toronto, ON: Multi-Health Systems.

Diamond. (2013). Executive functions. *Annual Review of Psychology*, *64*, 135–168.

Dickstein, D. P., Treland, J. E., Snow, J., McClure, E. B., Mehta, M. S., Towbin, K.E., et al. (2004). Neuropsychological performance in pediatric bipolar disorder. *Biological Psychiatry*, *55*, 32–39.

Duff, K., Schoenberg, M. R., Scott, J. G., & Adams, R. L. (2005). The relationship between executive functioning and verbal and visual learning and memory. *Archives of Clinical Neuropsychology*, *20*, 111–122.

Frost, L. A., Moffitt, T. E., & McGee, R. (1989). Neuropsychological correlates of psychopathology in an unselected cohort of young adolescents. *Journal of Abnormal Psychology*, *98*, 307–313.

Glahn, D. C., Bearden, C. E., Caetano, S., Fonseca, M., Najt, P., Hunter, K., et al. (2005). Declarative memory impairment in pediatric bipolar disorder. *Bipolar Disorders*, *7*, 546–554.

Golden, C. J., Freshwater, S. M., & Golden, Z. (2003). *Stroop color and word test children's version for ages 5–14*. Wood Date, IL: Stoelting Co.

Gunther, T., Holkamp, K., Jolles, J., Herpertz-Dahlmann, B., & Konrad, K. (2004). Verbal memory and aspects of attentional control in children and adolescents with anxiety disorders or depressive disorders. *Journal of Affective Disorders*, *82*, 265–269.

Hale, J. B., & Fitzer, K. R. (2015). Evaluating orbital-ventral medial system regulation of personal attention: A critical need for neuropsychological assessment and intervention. *Applied Neuropsychology: Child*, *4*, 106–115.

Heaton, R. K., Chelune, G. J., Talley, J. L., Kay, G. G., & Curtiss, G. (1993). *Wisconsin card sorting test manual: Revised and expanded*. Lutz, FL: PAR.

Henin, A., Mick, E., Biederman, J., Fried, R., Wozniak, J., Faraone, S. V., et al. (2007). Can bipolar disorder-specific neuropsychological impairments in children be identified? *Journal of Consulting and Clinical Psychology*, *75*, 210–220.

Hill, B. D., Alosco, M., Bauer, L., & Tremont, G. (2012). The relation of executive functioning to CVLT-II learning, memory, and process indexes. *Applied Neuropsychology: Adult*, *19*, 198–2006.

Jordan, L. L., Tyner, C. E., & Heaton, S. C. (2013). Cognitive predictors of verbal memory in a mixed clinical pediatric sample. *Behavioral Sciences*, *3*, 522–535.

Kavanaugh, B., & Holler, K. (2015). Brief report: Neurocognitive functioning in adolescents following childhood maltreatment and evidence for underlying planning & organizational deficits. *Child Neuropsychology*, *21*, 840–848.

Kolb, B., & Whishaw, I. Q. (1990). *Fundamentals of human neuropsychology* (3rd ed.). New York, NY: W. H. Freeman.

Lauer, R. E., Giordani, B., Boivin, M. J., Halle, N., Glasgow, B., Alessi, N. E., et al. (1994). Effects of depression on memory performance and metamemory in children. *Journal of the American Academy of Child & Adolescent Psychiatry*, *33*, 679–685.

Lezak, M. D., Howieson, D. B., & Loring, D. W. (2004). *Neuropsychological assessment* (4th ed.). New York, NY: Oxford University Press.

McClure, E. B., Treland, J. E., Snow, J., Dickstein, D. P., Townbin, K. E., Charney, D. S., et al. (2005). Memory and learning in pediatric bipolar disorder. *Journal of the American Academy of Child and Adolescent Psychiatry*, *44*, 461–469.

Myers, R. (1990). *Classical and modern regression with applications* (2nd ed.). Boston: Duxbury.

O'Hara, R., Coman, E., & Butters, M. A. (2006). Late-life depression. In P. J. Snyder, P. D. Nussbaum, & D. L. Robins (Eds.), *Clinical neuropsychology: A pocket handbook for assessment* (2nd ed., pp. 183–209). Washington, DC: American Psychological Association.

Rzezak, P., Guimaraes, C. A., Fuentes, D., Guerreiro, M. M., & Valente, K. D. (2012). Memory in children with temporal lobe epilepsy is at least partially explained by executive dysfunction. *Epilepsy & Behavior*, *25*, 577–584.

Schaefer, L. A., & Hebben, N. (2014). Domains of neurobehavioral function and related neurobehavioral disorders. In K. J. Stucky, M. W. Kirkwood, & J. Donders (Eds.), *Neuropsychology study guide & board review* (pp. 50–75). New York: Oxford University Press.

Sheslow, D., & Adams, W. (2003). *Wide range assessment of memory and learning second edition administration and technical manual*. Lutz, FL: Psychological Assessment Resources.

Strauss, E., Sherman, E. M., & Strauss, O. (2006). *A compendium of neuropsychological tests: Administration, norms, and commentary* (3rd ed.). New York: Oxford University Press.

Temple, R. O., Davis, J. D., Silverman, I., & Tremont, G. (2006). Differential impact of executive function on visual memory tasks. *The Clinical Neuropsychologist*, *20*, 480–490.

Tremont, G., Halpert, S., Javorsky, D. J., & Stern, R. A. (2000). Differential impact of executive dysfunction on verbal list learning and story recall. *The Clinical Neuropsychologist*, *14*, 295–302.

Udal, A. H., Oygarden, B., Egeland, J., Malt, U. F., & Groholt, B. (2012). Memory in early onset bipolar disorder and attention-deficit/hyperactivity disorder: Similarities and differences. *Journal of Abnormal Child Psychology*, *40*, 1179–1192.

Wechsler, D. (1999). *Wechsler abbreviated scale of intelligence*. San Antonio, TX: The Psychological Corporation.

Wechsler, D. (2011). *Wechsler abbreviated scale of intelligence* (2nd ed.). San Antonio, TX: The Psychological Corporation.

Wechsler, D. (2003). *Wechsler intelligence scale for children* (4th ed.). San Antonio, TX: The Psychological Corporation.