

Executive Function, Coping, and Psychological Adjustment in Pediatric Brain Tumor Survivors

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Acknowledgments

Special thanks to Dr. Bruce Compas, Dr. Jennifer Thigpen, Leandra Desjardins, Rebecca Byram, Lindsay Holmes and members of the Stress and Coping Lab past and present. This project was supported by a gift from an anonymous donor and a grant from the National Cancer Foundation to Dr. Bruce Compas.

Abstract

While new treatments have increased the survival rate of pediatric patients with brain tumors, they have also left this population with many adverse cognitive, emotional, and behavioral outcomes. Prior research provides evidence to support an association between cognitive function and use of complex secondary control coping strategies (e.g., acceptance and cognitive reappraisal). In children with brain tumors and other populations of children with chronic illness, these coping strategies have been associated with fewer adjustment problems. The present study used cognitive assessments and questionnaires to measure cognitive function, coping strategies, and emotional and behavioral problems in children aged 6 to 16 years near the time of diagnosis of a brain tumor and at four follow-up time-points up to 2 years post-diagnosis. The associations between domains of cognitive function, coping strategies (primary control coping, secondary control coping, disengagement coping) and emotional and behavioral problems were examined using correlational analyses. Significant correlations were found between working memory and secondary control coping across all time-points. Correlations between secondary control coping and adjustment (including attention problems and symptoms of anxiety and depression) were also significant. There was no significant association between working memory and adjustment. Future directions and implications are discussed.

Introduction

Every year in the United States over 12,000 children under the age of 21 are faced with the significant stress that accompanies the diagnosis and treatment of cancer. While previously this diagnosis was most often fatal, over 80% of pediatric cancer patients now survive at least 5 years post-diagnosis (Jemal, Siegel, Xu & Ward, 2010). However, many adverse long-term effects accompany the treatments for cancer. Specifically for children with brain tumors, of whom over 4,000 are diagnosed each year in the United States, these adverse effects can include damage to brain development and neurocognitive function (Central Brain Tumor Registry of the United States [CBTRUS], 2012). Furthermore, these neurocognitive sequelae have unfavorable effects on long-term quality of life. For example, in a study of survivors of pediatric brain tumors 14–28 years post-diagnosis, 39% of survivors suffered disabilities, and 8% were incapable of self-care (Pietila et al., 2012). One of the key factors impacting the quality of life of this population is the ability to cope with the stress of a brain tumor and its treatment. This paper focuses on the links between cognitive function, coping, and psychological adjustment in pediatric brain tumor survivors.

Specifically, this study investigates the association between cognitive function – including executive function, working memory and overall intelligence – and how children cope with the stress of treatment of a brain tumor. These aspects of cognitive function have been shown to be associated with coping strategies in other pediatric populations (e.g., Campbell, Scaduto, Van Slyke, Niarhos, Whitlock & Compas, 2009; Hocking et al., 2011; Robinson et al., in press). By identifying this relationship in children with brain tumors, intervention therapies may be developed to help children cope with the stress of a malignant brain tumor diagnosis in order to improve their psychological outcomes and ultimately their long-term quality of life.

Cognitive Function

Pediatric brain tumor survivors face significant long-term deficits in numerous cognitive domains. These deficits continue throughout treatment and into recovery, with no evidence of improvement years after conclusion of treatment. Deficits have been found in cognitive domains including attention, executive function, psychomotor skills, processing speed, verbal memory, visual memory, and visual spatial skills (Robinson, Fraley, Pearson, Kuttesch & Compas, 2010; Shortman, Lowis, Penn, McCarter, Hunt, & Brown et al., 2013; Robinson, Fraley, Pearson, Kuttesch & Compas, 2013; Stargatt, Rosenfeld, Maixner, & Ashley, 2013). The most common domains affected are attention, memory, and information processing speed. These deficits range from small to large effect sizes, and the largest effect sizes are found in children diagnosed and treated before 7 years of age (Butler & Haser, 2006). Because these children are performing in multiple cognitive domains at or more than a full standard deviation below the mean of their healthy matched controls, even a small improvement in these domains may have a large effect on children's well-being (Robinson et al., 2013). Significant negative effects are also found in overall intelligence and academic achievement. Several studies have suggested the stress the brain undergoes during cranial radiation therapy may be one of several factors that contribute to these cognitive deficits (Butler & Haser, 2006).

Furthermore, research has begun to identify which specific variables such as tumor location, tumor type, age at diagnosis, and chemotherapy and radiation type, may moderate these deficits (Robinson et al., 2010; Shortman et al., 2013; Stargatt et al., 2013). While this research is still relatively recent, Robinson and colleagues (2013) found that age of diagnosis and treatment is associated with larger cognitive deficits across domains. However, other moderators have less consistent results across studies. Further research into both the specific mechanisms

that cause these cognitive deficits, as well as the resilience by certain sub-populations would provide valuable insight into how to better these treatments so as to protect the patient's long-term brain development while also treating the brain tumor and preventing relapse.

Coping with Stress in Childhood Illness

The diagnosis and treatment of a pediatric brain tumor are very stressful events in a child's life. The acute stressful event of diagnosis is followed by a period of chronic stress as the child's life is changed due to the demands of treatment, recovery, and survivorship. The chronic illness of pediatric cancer creates a unique stress context, as the level of stress may influence the course of the illness as well as levels of pain. Therefore, the child's ability to cope with stress is imperative to his or her well-being (Compas, Jaser, Dunn & Rodriguez, 2012). Because successful coping strategies require use of higher order thinking skills, the cognitive difficulties observed in pediatric brain tumor survivors may also impact their ability to cope.

Research has focused on the outcomes associated with the use of various coping strategies in several populations of children faced with chronic illness. A chronic illness is a health problem that lasts three months or more, affects a child's normal activities, and requires frequent hospitalizations, home health care, and/or extensive medical care (Mokkink, van der Lee, Grootenhuis, Offringa & Heymans, 2008). The challenges and stressors that accompany chronic illness are often unanticipated, uncontrollable, and functionally impairing for children and their parents. These stressors and challenges range in type and intensity. For example, in a study assessing cancer-related stressors in children and their families, stressors were categorized into three domains: daily role functioning, physical effects of cancer treatment, and uncertainty about cancer (Rodriguez, Dunn, Zuckerman, Vannatta, Gerhardt & Compas, 2011). Thus, such a diverse set of stressors may demand a range of coping strategies.

Coping may be defined as a collection of “purposeful, volitional efforts that are directed at the regulation of aspects of the self and the environment under stress” (Compas et al., 2012, p. 459). To understand the significance of various types of coping efforts, the structure of coping, and coping domains must be considered. Coping strategies have been identified in three domains by confirmatory factor analysis: primary control coping, secondary control coping, and disengagement coping (Compas et al., 2012; Connor-Smith, Compas, Wadsworth, Thomson & Saltzman, 2000; Miller, Vannatta, Compas, Vasey, McGoron, Salley & Gerhardt, 2009). Primary control coping includes efforts to directly act on the source of stress, or directly change one’s emotions toward the stressor. Three main types of primary control coping are problem solving, emotional modulation, and emotional expression. Secondary control coping refers to efforts made to adapt to a stressor, including cognitive reappraisal, acceptance, positive thinking, and distraction. Disengagement coping refers to efforts to separate from the stressor, including denial, avoidance, and wishful thinking (Compas et al., 2012).

A recent review by Compas et al. (2012) assessed the role of these coping strategies in the context of pediatric chronic illness, specifically diabetes, chronic pain, and cancer. Across the studies included in this review, secondary control coping has been found to be the most effective in successful adaptation to chronic illness in children. The coping strategies involved in secondary control coping such as acceptance, cognitive appraisal, and distraction are most appropriate for the uncontrollable aspects of chronic illness, providing a maximal fit for the demands of the stressor with which they must cope. Primary control coping has mixed outcomes, varying across type of illness, perhaps reflecting the difficulty of the multiple types of stress involved in chronic illnesses. Disengagement coping has been consistently associated with poorer adjustment (Compas et al., 2012). Furthermore, Compas and colleagues suggest that the

neurocognitive sequelae of treating chronic illness, such as the rigorous treatments of chemotherapy and cranial radiation faced by brain tumor patients, may impede the patient's ability to cope with the stress of their illness. They have identified this as an area for future research that is of high priority.

Relationship Between Cognitive Function and Coping

Coping requires strength of complex higher order thinking skills. Therefore if children coping with the diagnosis and treatment of a brain tumor suffer deficits in cognitive abilities, it follows that they may also have difficulties coping effectively. Empirical evidence has established precedence for the relationship between cognitive functioning and the ability to cope. In young adults, working memory is significantly associated with cognitive appraisal and secondary control coping. Working memory, an aspect of executive function, is the short-term integration, processing, and retrieval of information. Working memory is of particular relevance to emotion regulation and secondary control coping, specifically cognitive reappraisal (Andreotti et al., 2013). For example, Schmeichel and Demaree (2010) found that in a sample of young adults, working memory capacity was positively associated with spontaneous emotion regulation, specifically suppression of facial expression and lower self-reported affect. While emotion regulation and coping are not synonymous, they are linked by an individual's ability to cognitively reappraise the stressor (Andreotti et al., 2013).

In childhood survivors of acute lymphocytic leukemia (ALL), the specific executive function domains of working memory, cognitive flexibility, and self-monitoring are positively associated with both primary control coping, and secondary control coping (Campbell et al., 2009). This study examined executive function, coping strategies, and behavioral problems in children with ALL and healthy matched controls. Similar to the findings in brain tumor

survivors, the survivors of ALL showed significantly lower levels of working memory when compared to healthy matched controls. Furthermore, Campbell and colleagues confirmed that secondary control coping fully mediates the relationship between executive function and behavioral problems in survivors of childhood ALL (Campbell et al., 2009).

In a literature review that compared cognitive effects of treatment for childhood ALL to pediatric brain tumors, cognitive deficits in the domains of memory and attention appear in both groups (Butler & Haser, 2006). Therefore the literature supports the hypothesis that a similar mechanism may occur in survivors of brain tumors. However, Butler and Haser (2006) found more severe deficits in broader cognitive domains such as language and visual-spatial abilities in survivors of brain tumors, which were attributed to the cranial radiation therapy endured by brain tumor patients but not those with ALL.

In another pediatric population coping with chronic illness, specifically in children coping with functional abdominal pain, an association between executive function, attention regulation, and coping has been observed. Executive function includes aspects of attention regulation such as selective attention, sustained attention, and attentional control (Hocking et al., 2011). Attention may play a unique role in the coping process. Initially, attention orients an individual toward potential sources of stress, and appraises the stressor by assessing its immediacy and controllability. Then some attentional resources are diverted to generate ways to cope. Once a coping strategy is selected, attention is focused on enacting the coping strategy as well as assessing changes in the stressor, environment and internal state (Compas et al., 2012). Similar to the mediation effects found by Campbell et al. (2009), the association between executive function and anxiety was mediated by secondary coping in children with abdominal pain (Hocking et al., 2011).

Building on this emerging body of evidence, the current study examined the associations among an aspect of executive function (working memory), coping, and attention problems and symptoms of anxiety and depression in a sample of children diagnosed with and being treated for a brain tumor. This study tested several hypotheses: (1) Levels of executive function, specifically working memory, will be significantly positively associated with use of secondary control coping; (2) attention problems and symptoms of anxiety and depression will be associated with lower cognitive function; and (3) children's use of secondary control coping will be related to lower attention problems and symptoms of anxiety and depression.

Method

Participants

Participants were 32 children diagnosed with a brain tumor between 6 and 16 years of age. At baseline assessment children were on average 10.8 years old ($SD = 3.0$), and 65.5% ($n = 21$) were male, 62.5% ($n = 20$) White/Caucasian, 25% ($n = 8$) Black/African-American, and 12.5% ($n = 4$) other. With regard to type of treatment, 56.3% ($n=18$) received surgery only, 15.6% ($n=5$) received chemotherapy, and 40.6% ($n=13$) received radiation therapy. With regard to disease severity, 59.4% ($n=19$) had WHO grade I/II tumors, and 40.6% ($n=13$) had WHO grade III/IV tumors. WHO grades are determined based on how abnormal the tumor cells and the tumor tissue look under a microscope. These grades are an indicator of how likely the tumor is to grow and spread, with higher graded tumors being more likely to grow and spread rapidly.

Measures

Demographic and medical data. Parents provided demographic information regarding their level of education, race/ethnicity, and family income. Participants gave permission for the research staff to access medical data, where the children's diagnosis and treatment information

was extracted.

Executive function. The Digit Span Subtest of the Wechsler Intelligence Scale for Children Fourth Edition (WISC-IV; Wechsler, 2003) was used to assess working memory. The Digit Span subtest is used as an indicator of working memory ability and attention. This task requires participants to repeat back lists of numbers, and to recite them in reverse order. The Wechsler intelligence scales have demonstrated excellent internal consistency and test-retest reliability, and convergent and discriminant validity have been established (Wechsler, 2003).

The Behavior Rating Inventory of Executive Function (BRIEF) questionnaire was completed by parents to assess symptoms of executive function difficulties, specifically difficulties with skills of working memory, initiation, planning and organizing, and emotional control (Gioia, Isquith, Guy & Kenworthy, 2000a). For the purposes of this study, the Working Memory subscale (BRIEF-WM; Gioia et al., 2000a) was used as an indicator of parents' concerns of children's working memory abilities. The BRIEF-WM consists of 10 items rated using a 3-point Likert scale (never, sometimes, or often). Items are designed to assess the capacity of the child to hold information in mind for the purposes of completing a task (Gioia et al., 2000a). The BRIEF-WM *T*-score is age- and gender-standardized with a mean of 50 ($SD = 10$), with higher ratings indicative of greater perceived difficulty and ratings of 60 and above indicating clinical significance. The BRIEF-WM demonstrates appropriate internal consistency $\alpha = .89-.92$, and test-retest reliability, $r = .82-.85$ (Gioia et al., 2000a; Gioia, Isquith, Guy, & Kenworthy, 2000b).

Children's emotional and behavioral problems. Parents completed the Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2001) to assess their children's attention problems and symptoms of anxiety and depression. The CBCL includes a 118-item checklist of problem

behaviors that parents rate as 0 (not true), 1 (somewhat or sometimes true), or 2 (very true or often true) of their child in the past six months. Reliability and validity are well established for the CBCL and normative *T*-scores are derived from parents' reports on a nationally representative sample of children and adolescents ages 6-17 years old (Achenbach & Rescorla, 2001). The Attention Problems and Anxious-Depressed scales were used for analyses.

Children's coping. The Responses to Stress Questionnaire-Brain Tumor version (RSQ-BT; Connor-Smith et al., 2000; Miller et al., 2009; Rodriguez et al., 2011) was used to obtain children's reports of how they cope with the stress of a brain tumor. The RSQ-BT includes a list of 12 cancer-related stressors (e.g., missing school, frequent hospital or clinic visits, changes in personal appearance), and 57 items reflecting voluntary (coping) and involuntary (automatic) stress responses of children in response to cancer-related stressors. For the purpose of this study, only the three voluntary coping scales are reported. The coping scales include: primary control coping (i.e., problem solving, emotional modulation, emotional expression), secondary control coping (i.e., acceptance, cognitive restructuring, positive thinking, distraction), and disengagement coping (i.e., avoidance, denial, wishful thinking). To control for response bias, proportion scores were calculated by dividing the total score for each factor by the total score for the entire RSQ (Oswiecki & Compas, 1998, 1999; Vitaliano, Maiuro, Russo, & Becker, 1987). All but one internal consistency for child reports of primary control, secondary control, and disengagement coping across three time-points ranged from $\alpha = .64 - .89$ with a mean $\alpha = .82$. Child reports of disengagement coping at T4 was the outlier, with an internal consistency of $\alpha = .43$. The factor structure of the RSQ has been supported in confirmatory factor analytic studies with children and adolescents from a wide range of ethnic and cultural backgrounds coping with a wide range of stressors (e.g., Benson, Compas, Layne, Vandergrift, Pasalic, Katalinski &

Pynoos, 2011; Compas, Beckjord, Agocha, Sherman, Langrock, Grossman, Dausch, Glinder, Kaiser, Anderson-Hanley & Luecken, 2006; Connor-Smith et al., 2000; Connor-Smith & Calvete, 2004; Wadsworth, Rieckmann, Benson, & Compas, 2004).

Procedure

Participants 6 to 16 years of age with a diagnosis of a pediatric brain tumor were identified by a pediatric neurosurgeon or pediatric medical oncologist at Vanderbilt Children's Hospital. These patients were a subset of a larger sample of participants in a study assessing overall neurocognitive and psychological functioning of pediatric brain tumor patients. The participants were recruited from Vanderbilt Children's Emergency Department, the Pediatric Neurosurgery Clinic, or the Hematology/Oncology Clinic at Vanderbilt Children's Hospital. Patients were excluded if there was recurrence of a previous cancer or a previous history of another form of cancer.

Study participation included completion of neurocognitive assessments and questionnaires at five time-points: (T1) prior to surgery, (T2) 4 to 6 weeks post surgery/pre adjuvant treatment, (T3) 6 months post diagnosis, (T4) 12 months post diagnosis, (T5) 24 months post diagnosis. Neurocognitive assessments included measures of general intellectual functioning and executive function. Parents completed questionnaires assessing emotional, behavioral, and social functioning, executive function, and coping.

For the purposes of this investigation, data was used from assessments at baseline (T1), 6 months post diagnosis (T3), 12 months post diagnosis (T4) and 24 months post diagnosis (T5). At the first baseline assessment prior to surgery, participants completed the WISC-IV Digit Span subtest. Parents completed the BRIEF and CBCL questionnaires, as well as a demographics

questionnaire. At all follow up assessments (T3, T4, T5), parents completed the BRIEF and CBCL questionnaires, and children completed the BT-RSQ.

Statistical Analysis

Pearson correlation coefficients were conducted to evaluate associations between children's working memory performance, children's self reports of coping, parents' reports of children's working memory difficulties, and parents' reports of children's attention problems and symptoms of anxiety and depression.

Results

Descriptive Statistics

Means, standard deviations, and sample sizes are reported in Table 1 for children's performance on the Digit Span subtest of the WISC-IV, parents' reports of children's working memory problems on the BRIEF, children's self reports on coping on the RSQ, and parents' reports of attention problems and symptoms of anxiety and depression on the CBCL. Children's performances on the Digit Span subtest of the WISC-IV are reported as standard scores. Children's reports of coping are reported as proportion scores to control for response bias. The proportion scores were calculated by dividing the total score for each factor by the total score for the full measure. Parents' reports of children's working memory problems on the BRIEF and attention problems and symptoms of anxiety and depression on the CBCL are reported as standardized *T* scores.

This sample of children with brain tumors performed approximately one-half standard deviation below the normative mean on the Digit Span subtest of the WISC-IV ($M = 8.76$, $SD = 2.85$). This sample also scored approximately half a standard deviation above the normative mean on the BRIEF ($M = 55.46$, $SD = 11.30$). Because the BRIEF is a parent report of

children's problems with executive function, this higher score indicates more reported problems with working memory. Similarly, parents' reports of children's attention problems on the CBCL scored at least a half standard deviation above the normative mean across all time-points, and parents' reports of children's symptoms of anxiety and depression on the CBCL also scored above the normative mean.

Correlational Analyses

Bivariate correlations of children's working memory as measured by the Digit Span subtest of the WISC-IV, children's reports of coping, and parent's reports of attention problems and symptoms of anxiety and depression are reported in Table 2. As hypothesized, working memory at baseline was significantly and positively correlated with secondary control coping across all time-points (T3: $r = .57$, T4: $r = .56$, T5: $r = .69$). Furthermore, in cross-sectional analyses, secondary control coping was significantly and negatively correlated with attention problems at T3 and T4 (T3: $r = -.51$, T4: $r = -.74$). At T5, secondary control coping was negatively associated with attention problems, however this correlation was not significant ($r = -.26$, $p = .18$). Similarly, in cross sectional analyses secondary control coping was significantly and negatively associated with symptoms of anxiety and depression at T3 and T4 (T3: $r = -.51$, T4: $r = -.54$) and this negative correlation was not significant at T5 ($r = -.23$, $p = .20$). Across time-points, secondary control coping at T3 was significantly associated with attention problems ($r = -.70$) and symptoms of anxiety and depression ($r = -.55$) at T4, and secondary control coping at T4 was significantly associated with attention problems at T5 ($r = -.73$). Contrary to the hypothesis, working memory at baseline was not significantly associated with attention problems or symptoms of anxiety and depression at any follow-up assessment.

As a secondary analysis, bivariate correlations were performed between baseline working memory and primary control coping, secondary control coping, and disengagement coping at all time-points (Table 3). Across all three time-points, working memory was only significantly associated with secondary control coping.

Correlations were also performed between the BRIEF parents' reports of children's working memory problems, children's baseline working memory, coping, and adjustment. Interestingly, BRIEF Working Memory scores were significantly associated with secondary control coping at T3 and T4 (T3: $r = -.75$, T4: $r = -.65$), and were significantly associated with attention problems and symptoms of anxiety and depression at all time-points (r 's range from .39 to .79). However, BRIEF Working Memory scores were not significantly associated with children's working memory as measured by the Digit Span.

Discussion

The diagnosis of a brain tumor presents children and families with a set of stressors related to the disease itself, treatment, and survivorship. Thus it is important to understand how children with brain tumors cope with these stressors given the diversity and breadth of the challenges they face. Furthermore, many of these children suffer cognitive difficulties due to their illness and treatment (Robinson et al., 2010, 2013; Shortman et al., 2013; Stargatt et al., 2013). Because of the higher order thinking skills demanded of successful coping skills, it is also important to consider the impact these cognitive difficulties may have on pediatric brain tumor survivors' ability to cope with their unique situations. The current study is the first to investigate the relationships between executive function, coping, and psychological adjustment in pediatric brain tumor survivors.

In order to evaluate the primary hypothesis that executive function is associated with secondary control coping, correlational analyses were performed. Children's baseline (near the time of their diagnosis and surgery) performance on a standardized measure of working memory was significantly associated with children's self reports of secondary control coping at 6, 12, and 24 months post-diagnosis (r 's ranged from .57 - .69). Further, secondary analyses that examined all three established domains of coping—primary control coping, secondary control coping, and disengagement coping—found no significant associations between working memory and primary control coping or disengagement coping, emphasizing the specificity of the relationship between working memory and secondary control coping. This finding supports the current evidence for this relationship in other populations (e.g., Andreotti et al., 2013; Campbell et al., 2009; Hocking et al., 2011).

Correlational analyses were also performed to assess the relationship between secondary control coping and emotional and behavioral problems. Because of the uncontrollable nature of the stressors that accompany the diagnosis of a brain tumor, it was hypothesized that use of secondary control coping would be associated with better adjustment. This association is also supported by empirical evidence from studies of other pediatric populations coping with chronic illness (Compas et al., 2012). For these analyses, children's reports of coping and parents' reports of their children's attention problems and symptoms of anxiety and depression were used. In cross-sectional analyses and across time-points, children's use of secondary control coping was significantly associated with fewer attention problems as well as fewer symptoms of anxiety and depression at 6 and 12 months post-diagnosis (r 's ranged from -.51 to -.74). Interestingly, though these correlations support the hypothesis, no correlations were significant at 24 months post-diagnosis. Perhaps this suggests that the stressors these children are facing have changed by

two years post-diagnosis, and that secondary control coping is no longer the most appropriate coping style given the demands of the stressors. Compas and colleagues (2012) emphasize that a maximal fit between coping and the demands of specific challenges is key to effective coping.

Next, it is interesting to consider the directionality of the relationship between attention problems and coping. Several studies consider attention to be either encompassed by, or very closely related to, executive function (Hocking et al., 2011; Miyake & Friedman, 2012). Therefore, it is plausible to hypothesize that attention problems make it more difficult to engage in secondary control coping. However in this study, there was no association between working memory performance and attention problems as measured by the CBCL, nor was there an association between attention problems at an early time-point with secondary control coping at later assessments. Miyake and Friedman (2012) identify attention as a component of the inhibition domain of executive function, and working memory as a component of the updating domain of executive function. Thus it is possible that these different domains of executive function each play an independent role in coping. Further investigation is necessary to clarify the relationship between executive function, attention problems, and coping.

Lastly, correlational analyses were used to assess the relationship between children's working memory and parents' reports of attention problems and symptoms of anxiety and depression. Contrary to the hypothesis, there were no significant associations between children's working memory performance at baseline and parents' reports of adjustment at any follow up assessment. A secondary analysis was performed using the BRIEF-WM as a measure of parental concern about working memory problems. Greater perceived difficulties as indicated by the BRIEF-WM were correlated with more attention problems and more symptoms of anxiety and depression at all follow up assessments (r 's range from .43 to .79). However, the BRIEF-WM

scores were not associated with children's working memory performance as indicated by the WISC-IV Digit Span subtest. Therefore this correlation between parents' concern about working memory problems and parents' reports of adjustment may be indicative of parents' perspective of their children's overall functioning. In other words, parents that report problems with their children's psychological adjustment may simply be more apt to report problems with their children's executive function as well.

Though this study did not provide evidence for a relationship between pediatric brain tumor survivors' executive function and psychological adjustment, it does replicate findings in the literature that support the role of working memory in secondary control coping, and the importance of secondary control coping for children coping with chronic illness. These findings highlight the importance of addressing the problem of cognitive deficits in pediatric brain tumor survivors and suggest that there is an additional factor at stake in the lives of these children. Because working memory performance at diagnosis was highly correlated with secondary control coping two years after diagnosis ($r = .69, p < .01$), these cognitive deficits may have far reaching consequences in the psychological health of pediatric brain tumor survivors. Not only may these cognitive problems impact their academic performance, but they may also impact their ability to cope with day-to-day challenges into and beyond adolescence. There is currently research into possible cognitive remediation interventions for children with brain tumors. The findings of this study support the importance of testing such interventions, and offer a new window where a different intervention may be appropriate. There exists current research into interventions that target working memory in an emotional context to improve the underlying processes that serve both cognitive and emotional demands (e.g. Schweizer, Grahn, Hampshire, Mobbss & Dalgleish, 2013; Tang, Yang, Leve & Harold, 2012). Perhaps teaching these children

complex coping strategies will not only provide them with the tools necessary to cope effectively, but will also have some benefit on their overall cognitive function. On a broader level, the association between executive function and coping has been found across several populations, however it is still a fairly new area of research. This study reinforces the evidence for a relationship between executive function, specifically working memory, and secondary control coping.

This study had several limitations. First, the small sample size limited the statistical power of the study. Because of the longitudinal design of the study, and the complicated demands of working with children undergoing treatment for a brain tumor, a portion of the participants were missing data at one or more time-points. Also, the child self report BT-RSQ is only applicable to children older than 9 years of age. Thus our initially small sample was further limited by this measure. Furthermore, our sample was fairly homogeneous as a result of the constraints of a one-site study. There may be some self-selection in which families have the resources and are in the proximity to receive treatment at Vanderbilt Children's Hospital. For similar studies in the future, recruiting from multiple sites may help reduce both of the above limitations. Also, children's self-reports of coping were used for the analyses in this paper. It would be beneficial to use multiple informants in the future in order to gain a more complete perspective of how children cope with the diagnosis of a brain tumor.

However, given these limitations, this study accomplished several very difficult tasks. First, this is the first study to assess the relationship between executive function and coping specifically in pediatric brain tumor survivors. Second, the larger study from which this data was obtained is the first of any kind in this population to obtain a measure of functioning before the subjects receive surgery. By finding these patients and working with them from the time

they are diagnosed with a brain tumor, through their treatments, and into survivorship, we are better able to understand the demands of their illness, and the ways in which they and their families respond.

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Table 1. Means, Standard Deviations, and Sample Sizes of All Measures used in Analyses

Measure	Time point	n	Mean	SD
Digit Span (WISC-IV)	1	25	8.76	2.85
Working Memory Problems (BRIEF)	1	26	55.46	11.30
Primary Control Coping (RSQ-BT)	3	14	.18	.04
	4	14	.17	.05
	5	16	.16	.04
Secondary Control Coping (RSQ-BT)	3	14	.28	.07
	4	14	.31	.08
	5	16	.28	.07
Disengagement Coping (RSQ-BT)	3	14	.16	.04
	4	14	.16	.04
	5	16	.16	.02
Attention Problems (CBCL)	3	23	55.78	6.84
	4	20	58.05	9.24
	5	22	58.55	11.00
Anxiety/Depression Symptoms (CBCL)	3	23	54.70	6.59
	4	20	56.80	9.23
	5	22	53.23	6.29