Temperament and Social Behavior in Pediatric Brain Tumor Survivors and Comparison Peers

Dissertation

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

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2011

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Abstract

It is well documented that pediatric brain tumor survivors experience neurocognitive and social deficits following treatment. Our work has demonstrated that, compared to peers, survivors demonstrate differences in social behavior. Unfortunately, the there is little research to date documenting possible explanations for the patterns of social behavior in this population.

Utilizing modern models of social information processing, the current study examined temperament (i.e., effortful control, positive affect/surgency, negative affect) relative to children’s social behavior. Given the biological bases of temperament, it was hypothesized that treatment would have a detrimental effect on children’s temperament. Temperament was also examined as a potential explanation for survivors’ social behavior.

Pediatric brain tumor survivors ($n = 75$) without known progressive disease and no longer on treatment were recruited for the current project. Peers ($n = 67$) matched for gender, race, and age were selected from each survivor’s classroom to serve as a comparison group. Classmates reported on survivors’ and peers’ social behaviors (i.e., Leadership-popularity, Prosocial, Aggressive-disruptive, Sensitive-isolated, and Victimization). Data regarding children’s temperament were collected from parent and self-report measures. A performance based measure of attention was also administered to children.
As expected, survivors performed more poorly than peers on the performance based measure of attention. They were also rated lower on measures of effortful control and positive affect/surgency. A trend suggested greater negative affect in survivors. Temperament did not aid in explaining differences in social behavior (i.e., Leadership-popularity, Sensitive-isolated, Victimization) between the two groups. Analyses indicated that effortful control mediated the association between group (brain tumor vs. comparison) and prosocial behavior for moderate or high levels of parent reported surgency, but not for low levels of surgency. Effortful control was also found to mediate the association between group and aggressive-disruptive behavior at moderate or high levels of parent reported surgency, but not at low levels of surgency. Survivors of pediatric brain tumors appear to be at risk for deficits in social behavior and temperament. Contrary to expectations temperament did not provide an explanation for differences in social behavior between the survivors and comparison peers. Future work should continue to consider other aspects of social information processing models in identifying factors that may influence social behavior and social outcomes for survivors.
This document is dedicated to my husband.
Acknowledgements

I would like to thank my advisor, Kathy Vannatta, for her continued encouragement and mentorship.

I would also like to thank Cindy Gerhardt, Michael Vasey, and Steven Beck for their assistance in the preparation of this document.

Finally, I would like to thank the schools and families who generously contributed to this work.
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Collectively, brain tumors are a heterogeneous group of malignancies, which vary by histology and location. They are the second most common form of pediatric cancer, affecting 2200 children under 20 each year (Ries et al., 1999). Recent advances in diagnostic techniques and treatment have led to five-year survival rates that now approach approximately 74% as opposed to 51% in the 1970’s (ACS, 2006; Jemal et al., 2009). However, the sensitive location of these tumors, as well as the necessity for treatments that penetrate the central nervous system (CNS) increase risk for neurocognitive deficits and psychosocial difficulties among affected children (Fuemmeler, Elkin, & Mullins, 2002).

In children under the age of 15, the most common brain tumors are astrocytomas (50%), primitive neuroectodermal tumors (PNET) (23%), other gliomas (15%), and ependymomas (9%) (Ries et al., 1999). Treatment varies depending upon diagnosis, histology, location, and demographic factors. The goal of treatment is to find an optimal balance between tumor reduction or eradication and collateral damage or morbidity. The first approach to treating most brain tumors is surgical resection, which aims to reduce the tumor size and provide a sample for histological diagnosis (Ullrich & Pomeroy, 2003). Surgery is, however, typically avoided for those tumors located in the brainstem, as successful resection is unlikely due to the extent of infiltration in this critical region. This is particularly true for diffuse brainstem gliomas, which account for 58% to 75% of all pediatric brainstem gliomas (Mueller & Chang, 2009).
For many children with brain tumors, radiation therapy remains the standard of care. It is frequently used as adjuvant therapy, particularly when postoperative staging suggests incomplete removal of the tumor. Radiation can be directed to the entire brain (i.e., whole brain radiation) or specifically to the tumor region (i.e., focal radiation). Radiation has been implicated as the treatment leading to the most deleterious psychosocial outcomes for survivors of pediatric brain tumors (Mulhern & Butler, 2004). Significant declines in core neurocognitive functions including attention, memory, and processing speed have been identified. These deficits have been linked to post-treatment neuro-anatomical changes and are thought to underlie progressive declines in overall IQ and other functional outcomes for survivors (Mulhern & Butler, 2004). As such, there has been increasing attention to reducing radiation dosage and using focal radiation when possible to avoid damage to surrounding healthy tissue (Conklin, Li, Xiong, Ogg, Merchant, 2008). This tailored approach does not come without concerns, as it may result in incomplete treatment of critical tissue area and greater risk for relapse.

Chemotherapy is also a commonly used adjuvant treatment designed to reduce tumor mass and impede cell growth. However, the most effective combinations of chemotherapy for different tumor types continue to be of question and are a common focus in clinical trials (Karajannis, Allen, & Newcomb, 2008). Some institutions have begun to use high-dose chemotherapy in conjunction with concurrent autologous bone marrow or peripheral-blood stem cell reconstitution (Ullrich & Pomeroy, 2003). One challenge in using chemotherapy to treat brain tumors is that traditional chemotherapies are limited by their ability to permeate the blood-brain barrier. As a result, newer chemotherapy agents have been developed with this purpose in mind. Unfortunately, this
CNS penetration has been linked to neurotoxicity and declines in cognitive functioning (Butler, Hill, Steinherz, Meyers, & Finlay, 1994).

Neurocognitive decline has been well documented in pediatric brain tumor survivors; however, the developmental consequences of the disease and its treatment are not well understood. Interestingly, research addressing outcomes among children treated for cancers not located in the CNS has generally found that these children adjust well (Noll & Kupst, 2007). Findings by our own research group have suggested enhanced rather than problematic peer relationships for children who had returned to school during initial treatment for cancer not involving the CNS (Noll, et al., 1999). Across numerous studies, there is a general consensus that survivors of non-CNS cancers generally do not have poorer social outcomes than their peers (Fuemmeler, Mullins, & Carpentier, 2006; La Greca, Bearman, & Moore, 2002). Unfortunately, social outcomes for children treated for brain tumors are not as positive (Fuemmeler, Elkin, & Mullins, 2002). This is also congruent with findings that children with malignancies outside the CNS may be at risk for social difficulties when receiving more intensive CNS-directed treatment (Vannatta, Gerhardt, Wells, & Noll, 2007).

Research on social outcomes for pediatric brain tumor survivors has primarily relied on parent, or at times self or teacher, report on standardized questionnaires. Using this methodology, some negative outcomes have been reported. For example pediatric brain tumor survivors (ages 4 to 16) were found to demonstrate less social competence on the Child Behavior Checklist (CBCL; Achenbach & Edelbrock, 1983) reflecting participation or involvement in activities, number of friends and contact with friends, and performance in school, compared to non-CNS cancer survivors (Carpentieri, Mulhern,
Douglas, Hanna, and Fairclough, 1993). Within the brain tumor group, parents reported a significant increase in social problems (e.g., loneliness, not getting along with others, being teased, not well liked) and problems related to social competence between initial diagnosis and 2-3 years later. In this group, declining social behaviors were associated with increases in abnormal brain volume and those with tumors located outside the third-ventricle region of the brain. Brain tumor survivors have also been found to demonstrate greater social problems on the CBCL than children with juvenile rheumatoid arthritis (JRA) as well as problems related to social skills on the Social Skills Rating System (SSRS; Gresham & Elliott, 1990), a second parent report measure (Bonner et al., 2008). Carey et al. (2001) found that parents reported that brain tumor survivors had clinically significant social problems on the CBCL, and a trend for social problems on the SSRS, while teachers and children reported no such difficulties. Similar findings have been reported by Poggi et al. (2005) who found that 23% of brain tumor survivors had significant social problems and trouble with socialization, particularly significantly impaired social skills according to parent report on the Vineland Adaptive Behavior Scale (VABS; Sparrow, Balla, & Cicchetti, 1984). Sands et al. (2005) have also found that parents report clinically significant social problems in addition to low average social functioning on the Child Health Questionnaires (CHQ; Landgraf, Abetz, & Ware, 1996). Furthermore, social problems have been reported for survivors by parents, teachers, and children in a sample of low-grade astrocytoma survivors (Aarsen et al., 2005). Lastly, children with brain tumors have been reported to have a lower quality of life with regards to social outcomes than healthy controls (Bhat, et al., 2005).
Qualitative interviews with pediatric brain tumor survivors and their parents have also shed light on some of the social challenges survivors may experience during childhood and adolescence. Boydell, Stasiulis, Greenberg, Greenberg, and Spiegler (2008) documented the sometimes contradictory feelings survivors’ experience. For example, they indicated that although survivors felt socially worthy and capable, they accepted the reality of some social incompetence related to difficulty with concentration, retaining knowledge, and participation in activities with peers. Many survivors reported limitations in their social lives, and some described being teased. There was also a notion that survivors found it challenging to engage with peers following treatment and that this led to feelings of isolation and loneliness.

Upton and Eiser (2006) interviewed mothers of children within two years of the child’s treatment for a brain tumor. Nearly half of the mothers said their child was socially isolated and many reported that although peers attempted to engage with their child, the child’s response discouraged peers from future attempts. Some mothers reported their child was teased or bullied because of their cancer treatment. For some children, social relationships were described as “satisfactory” but were more limited than in the past. In this same study, parent questionnaire data indicated that pediatric brain tumor survivors evidenced peer relationship problems and poor prosocial behavior compared to norms on the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997). Teachers also felt survivors experienced peer relationship problems and that these problems were related to social impairment and burden to others.

Overall, what is known about social outcomes for pediatric brain tumor survivors has primarily resulted from parent and teacher report on questionnaires concerning broad
indicators of social functioning. Often these findings are interpreted in relation to instrument norms which may or may not constitute an optimal reference point for samples of survivors that are not random samples of the same reference group (Achenbach & Howell, 1993; Sandberg, Meyer-Bahlburg, & Yager, 1991). In contrast, our own research group has used a methodology widely employed by developmental psychologists in which peer perspectives of survivor’s social behaviors are obtained and examined relative to classmates who have not been affected by a severe or chronic illness. Parents, who primarily observe their children at home, and teachers, who may not be aware of the full extent of children’s behavior with peers, may provide information that lacks details of children’s actual social interactions (Greener, 2000). Peers, on the other hand, may have more direct knowledge as they interact with classmates socially, and therefore are given the opportunity to observe a wide range of social behaviors (Parker & Asher, 1987). Relying on the report of classmates has additional benefits in that multiple reports can be averaged in order to reduce the impact of reporters’ response biases (Holmbeck, Li, Schurman, Friedman, & Coakley, 2002).

Using this methodology, we have documented differences in social behavior and acceptance between children treated for a brain tumor and comparison classmates matched for gender, age, and race. In a pilot study of 28 pairs of children, we found that peers, teachers, and survivors indicated that survivors demonstrated behavior reflecting social sensitivity and isolation more than comparison peers (Vannatta, Gartstein, Short, & Noll, 1998). No differences were found on scales measuring sociability and leadership or aggressive and disruptive behavior. Vannatta et al. (manuscript in preparation) recently used the same methodology in a sample 122 pediatric brain tumors survivors and 122
comparison children. These results also suggested that classmates viewed survivors as more sensitive and isolated. In addition, peers described survivors as more victimized, less aggressive and disruptive, and lower in leadership and popularity than comparison peers. Teachers perceived survivors as more prosocial while also more sensitive or isolated and less aggressive or disruptive. Child self-report indicated that survivors saw themselves only as less aggressive and disruptive compared to the self-report of comparison peers.

Pediatric brain tumor survivors are at significant risk for less than optimal social relationships (Fuemmeler, et al., 2002). Unfortunately, there is little research to date documenting possible explanations for the patterns of social behavior seen in this population. Poor social functioning is of great concern as forming peer relationships are a significant part of development during childhood and adolescence (Masten, et al., 1995). Furthermore, peer relationships are predictive of long-term functioning including social, educational, and job related domains (Gest, Sesma, Masten, & Tellegen, 2006; Parker & Asher, 1987). Epidemiological research suggests that adults who received treatment for brain tumors in childhood are at risk for unemployment and lower rates of marriage (Armstrong, et al., 2009; Mostow, Byrne, Connelly, & Mulvihill, 1991). Unfortunately, little research to date has delineated what leads to or accounts for poor developmental outcomes for these children. It is important to better understand the mechanisms contributing to the social behavior of survivors, both because these are important outcomes in their own right and they serve as risk factors for subsequent developmental difficulties in later adolescence and adulthood. This understanding may help us better
predict who may be at intermediate and long-term risk in order to help limit the developmental consequences of CNS disease and its treatment.

Several overlapping conceptual models have emerged and gained recognition that may help inform our understanding of factors that contribute to the social adjustment of pediatric brain tumor survivors. Well-established models of social information processing (Crick & Dodge, 1994) have increasingly been adapted to emphasize the role of neurocognitive deficits (Guralnick, 1999) as well as variations in emotion and emotion regulation (Lemerise & Arsenio, 2000), in the social interactions of normally developing children. Temperament models have been applied to understand how relatively stable characteristics in how children respond to environmental stimulation may affect behavior during interactions with peers (Eisenberg et al., 1995; Rothbart, 1989). Integration of these processes has been attempted under the umbrella of social cognitive neuroscience, emphasizing social cognitive processes while taking into consideration the neurological underpinnings of these processes (Yeates et al., 2007). This approach has been particularly concerned with the influence of neurological insult on the social cognitive development of children.

The authors propose that a number of risk and/or resilience factors can impede or promote social competence including characteristics inherent to the individual or environmental influences such as parenting or socioeconomic status (Yeates et al., 2007). While developmental theorists (e.g., Crick and Dodge, 1994) have also offered models examining processes social information processing and social outcomes in children, they have failed to consider the potential effects of neurological damage. Neurological impairment resulting from insult to the brain may be a risk factor interfering at any level
within the model. That is, neurological functioning may be predictive of a child’s ability to identify, reveal, and regulate emotions, to consider others’ intentions and feelings, and to engage in problem solving.

Social-affective processes are individual differences in the experience, perception, understanding, and regulation of emotion (Halberstadt, Denham, & Dunsmore, 2001). These processes are both volitional and nonvolitional and include a child’s awareness of their emotion, their interpretation of that emotion, and their associated behavioral response. It is thought that this behavior may potentially have positive or negative consequences as the child’s environment will react in response to this behavior. Although social information processing models have acknowledged emotion as an important component, they have generally failed to truly integrate the influence of emotion in other social processes (Guralnick, 1999). Social interaction requires individuals to recognize and manage their internal emotional reactions (Lemerise & Arsenio, 2000). One framework used to understand emotion, or affect, and behavior is temperament. Unfortunately, temperament has not been investigated in children treated for brain tumors. This is one framework which may be used to conceptualize individual differences as well as cross-situational consistency, in children. Given the biological underpinnings of temperament, it may be that these processes are affected by brain tumors and their treatment which may, in turn, influence social outcomes for these children.

Temperament has been defined by Rothbart and colleagues as constitutionally-based, individual differences in emotional, motor, and attentional reactivity to stimulus events and self-regulation (Rothbart, Sheese, & Posner, 2007; Rothbart & Bates, 2006).
Constitutional refers to the enduring biological make up of the individual, which may be influenced across time by heredity, maturation, and experience. Contemporary psychobiological theory suggests that temperament encompasses two reactive or motivational systems, as well as a regulatory, more voluntary, control system (Derryberry & Rothbart, 1997). The products of these systems are individual differences in emotion, cognition, and behavior which have foundations in specific biological structures (Derryberry & Rothbart, 1997; Derryberry & Tucker, 2006). Temperament is generally considered to be relatively stable and is thought to underlie personality development (Rothbart, 2007). It has also been linked to psychopathology (Phillips, Lonigan, Driscoll, & Hooe, 2002; Nigg, 2006) and social outcomes (e.g., Gunnar, Sebanc, Tout, & Donzella, 2003; Eisenberg, Fabes, Guthrie, & Reiser, 2000; Eisenberg, et al. 1995) in children.

The two motivational (involuntary) systems in temperament serve appetitive and defensive needs and begin to emerge during the early months of life (Rothbart et al., 2007). The appetitive system is responsible for an individual’s approach behavior. This system facilitates an individual’s response to the environment so that they direct themselves and their goals toward incentive. According to Gray this “behavioral activation system” is stimulated by signals indicating that approach behavior will be rewarded. This system is related to a general dimension of positive emotionality (Watson & Clark, 1992), which is proposed to be related to the personality variable Extraversion (Rothbart, 2007). Rothbart and colleagues (e.g., Ahadi, Rothbart, & Ye, 1993) have entitled this factor “Surgency,” whereas Phillips, et al. (2002) use the term Positive Affect/Surgency (PA/S). Surgency is characterized by approach behavior, sensation
seeking, activity level, impulsivity, sociability, positive anticipation, and low levels of shyness (Ahadi, et al., 1993; Rothbart, 2007).

The second motivational system, the defensive system, is related to fearful and withdrawn behavior. This system is described by Gray (1971) as a “behavioral inhibition system” in which children are likely to be sensitive to environmental cues signaling fear and predicting punishment, particularly in novel situations. When activated, this system promotes avoidant behavior and increased arousal. This system has been related to a general dimension of negative emotionality or the personality construct of Neuroticism (Watson & Clark, 1992). Rothbart and colleagues have labeled this defensive system Negative Affectivity (NA) and describe observable behaviors that include frustration, fear, discomfort, sadness, and soothability.

The third, regulatory temperament system has been labeled Effortful Control (EC) by Rothbart (2003) and colleagues. It should be noted that others (e.g., Eisenberg, et al., 1997) have described similar and overlapping self-regulatory constructs, including emotion regulation, behavioral regulation, and self-regulation. Evidence of EC is seen near the end of the first year of life, and EC further develops well into childhood (Rothbart et al., 2007). It has been defined as “the ability to inhibit a dominant response to perform a subdominant response” (Rothbart & Bates, 1998, p. 137). EC includes a child’s ability to “choose a course of action under conditions of conflict, plan for the future, and detect errors” (Rothbart, 2007). This self-regulatory system is expected to be involved in modulating the reactive systems (i.e., Surgency/NA) by activating attention or behavior and conversely, inhibiting behavior when necessary. It can include both cognitive and motor activation. EC is a complex system and is expected to include
processes involving attention, approach, withdrawal, attack, behavioral inhibition, and self-soothing (Rothbart, 1989). An individual is appropriately regulated when they are able to react spontaneously when such reactions are suitable, and react more cautiously when necessary.

EC is proposed to lie within the executive attention network, one of three neural attention networks (Rothbart et al., 2007). Although the first two networks (i.e., posterior attention, vigilance) are responsible for alerting and orienting, the executive attention network is responsible for conflict-resolution, including promotion and suppression of activation, between other brain networks (Posner & Petersen, 1990; Rothbart et al., 2007). The posterior attention network is responsible for orienting to sensory stimuli such as directing attention, visually, to an object in space (Posner & Rothbart, 1992). The vigilance network is responsible for helping an individual maintain an alert state. The executive attention system, or anterior attentional system, is proposed to be responsible for EC. This system has been implicated in tasks in which an individual is required to respond to stimuli involving conflict (e.g., Stroop-like tasks, etc.) (Fan, Flombaum, McCandliss, Thomas, & Posner, 2003; Simonds, Kieras, Rueda, & Rothbart, 2007).

Much of the focus of temperament research has been on personality development and psychopathology. Behavioral outcomes, including social outcomes, have been increasingly investigated with findings suggesting an association between temperament and social adjustment during childhood and adolescence. In general, negative affectivity or reactivity has been associated with or predictive of negative social outcomes. It is expected that children high in negative affect will be less affiliative as they are generally more sensitive to punishment within the environment and are likely to be more avoidant
of social interaction (Derryberry & Tucker, 2006). For example, Henderson, Fox, & Rubin (2001) found that maternal reports of negative reactivity at 9 months of age were positively related to social wariness, a composite of observed reticence and mother reported shyness, at 48 months. Interestingly, this relationship was moderated by gender, such that the relationship was found for boys but not for girls. Similarly, it has been reported that children who have high levels of behavioral inhibition system activity (BIS; similar to high NA) and low levels of behavioral activation system activity (BAS; similar to surgency) have a high risk for psychosocial maladjustment, including social anxiety (Coplan, Wilson, Frohlick, & Zelenski, 2006). This combination of high BIS and low BAS is often evidenced in avoidant children.

Negative emotionality (similar to NA) is associated with less socially appropriate behavior (e.g. well behaved), and high negative emotionality during early childhood has predicted declining social skills over time (Sallquist, et al., 2009). Negative emotionality is inversely related to socially appropriate behavior and prosocial/sociable (i.e., popularity, prosociality, and low social insecurity) behavior (Eisenberg, et al., 1995). Moreover, findings have consistently shown that negative emotionality moderates the association between behavioral regulation (an indicator of effortful control) and these positive social outcomes. This indicates that behavioral regulation and socially appropriate behavior may be correlated only for those children with high negative emotionality (Eisenberg, et al., 2000; Eisenberg, et al., 1997; Eisenberg, et al., 2003). In one study, negative affectivity during infancy was linked to aggression in childhood; however it appeared to be the anger/irritable components of NA, rather than the sadness component of NA that was responsible for this connection (Rothbart, Ahadi, & Hershey,
Interestingly in this same study, Rothbart et al. (1994) found that NA was positively associated with more adaptive social outcomes including help-seeking and prosocial behaviors related to empathy and guilt/shame. Rothbart et al. (1994) explain that NA may foster the development of help seeking behaviors because emotion-eliciting situations provide children the opportunity to be reinforced by eliciting help from others (i.e., distress is reduced when others help).

Children high in positive affect or surgency (PA/S) are expected to be generally positive and to direct much of their energy towards social affiliation because of the expectation and experience of social relationships as rewarding (Derryberry & Tucker, 2006). Children who are high on PA/S are described as outgoing, energetic, and dominant in interactions with peers and adults, whereas those low on PA/S tend to be quieter and inhibited (Shiner & Caspi, 2003). Interestingly, high levels of PA/S have been associated with social problems, as well as appropriate social skills. For example, Rothbart et al. (1994) found that high surgency was related to more aggressive behavior and fewer behaviors related to feelings of guilt and shame. Sallquist, et al. (2009) found reports of high positive emotionality at a young age was predictive of decreasing social skills for children over time, a finding that was stronger for boys than for girls.

Berden, Keane, and Calkins (2008) conducted a study in which they examined social preference and perceived acceptance as moderators of surgency/extraversion and externalizing behavior. They found that children higher in surgency were less well-liked by peers and had more externalizing problems according to parent and teacher report. Interestingly, girls with accurately perceived high peer acceptance who also were high in surgency did not have externalizing problems, suggesting that accurate perceptions of
peer acceptance was protective against the possible problematic relationship between
temperament and poor outcomes. Gunnar et al., (2003) conducted a study examining
associations between temperament (i.e., effortful control and surgency), cortisol
production, aggression, and peer rejection in preschool children. They found that children
who were high on surgency and low on effortful control were among the most aggressive
children in the sample and that aggressive children were more likely to be rejected by
peers. As noted above, there are some positive social outcomes associated with PA/S.
Parker-Cohen and Bell (1988) found that children who were more approaching were
rated as more socially responsive to peers. Further, they found that “easy” children (i.e.,
those characterized as approaching, adaptable, and with a positive mood) were more
sociable than “slow to warm up” children.

Voluntary motivational systems including effortful and attentional control and
self-regulation have consistently been reported to be positively related to good social
outcomes. For example, Spinrad et al. (2006) found that children’s socially appropriate
behavior was positively related to effortful control and negatively related to impulsivity,
whereas popularity with peers was positively related to effortful control. This study also
demonstrated that an initial assessment of effortful control at 4.5-7.9 years of age
predicted popularity and socially appropriate behavior two years later, and that initial
impulsivity was related to later socially inappropriate behavior. Both suppress/initiate and
motor components of effortful control have been linked to social competence including
prosocial behavior and communication skills (Dennis, Broman, Huang, & Gouley, 2007).

Effortful control has been reported to be predictive of academic competence in
children via its impact on social competence (i.e., social competence mediates the
relationship between effortful control and academic performance) (Valiente, Lemery-Chalfant, Swanson, & Reiser, 2008). Booth-LaForce and Oxford (2008) found that children with dysregulated temperament during infancy and poor inhibitory control actually increased in social withdrawal over time. In a sample of children and adolescents 8-18 years, Buckner, Mezzacappa, and Beardslee (2009) found that children higher in self-regulation, a construct overlapping with effortful control, were rated by parents to have more social competence, including being well liked, making friends easily, and enjoying being with others. These children self-reported being less involved with deviant peers than children who demonstrated less self-regulation. Specifically, children low in self-regulation reported having a lower quality and quantity of social support in their social network than children with high self-regulation.

Although one investigation of temperament in children with cancer included children with brain tumors (13% of the sample of children with cancer), results were not reported separately for these children (Miller, et al., 2009). Thus, there is currently no reported research on temperament (e.g., EC, PA/Surgency, NA) for children receiving treatment for a brain tumor. However, brain tumors and their treatment are associated with neurological insult, which may have adverse effects on the biological underpinnings of temperament systems. This potential connection is most clearly seen through research on documented attention problems in pediatric brain tumor survivors (Mulhern & Butler, 2004). As noted above, effortful control lies within the executive attention network, and attentional ability is a key component of effortful control (Rueda, Posner, & Rothbart, 2005). The relationship between attention and effortful control has been documented in studies examining both. For example, Simonds et al. (2007) found that children’s
performance on the Attention Network Test measuring alerting, orienting, and executive control correlated with parent report of children’s effortful control. Interestingly, Verstraeten, Vasey, Claes, & Bijttebier (2010) found that performance on the Test of Everyday Attention for Children (TEA-Ch; Manly, Robertson, Anderson, & Nimmo-Smith, 1999) correlated with parent report of effortful control for young children (i.e. 3rd and 4th graders) but not for older children (5th to 9th graders). This pattern was attributed to less variability in TEA-Ch scores for older children.

Attentional abilities have also been linked to social outcomes. Raver, Blackburn, Bancroft, and Torp (1999) found that attentional control was linked to higher peer social competence; however it was not related to peer social preference scores. This study also found that children with lower self-regulation skills were more often disliked by peers than children that were higher in self-regulation. Wilson (2003) demonstrated that attention shifting, described as shifting attention from negative to more positive affect, was positively related to children’s sharing behaviors. Further, aggressive/rejected children had greater difficulty shifting attention than other children. Attention problems, particularly sustained attention problems, have been linked to social problems in children (Andrade, Brodeur, Waschbusch, Stewart, & McGee, 2009). Other evidence for an association between attention and social outcomes in children stems from research on children with ADHD indicating that these children struggle with problematic peer relationships (Hoza, 2007; Stormont, 2001). Given the association between attention and effortful control and social outcomes, it is plausible to expect that if treatment for pediatric brain tumors has deleterious affects on attention in survivors, there may be adverse affects in both social outcomes and effortful control.
Most work investigating attention problems in children treated for brain tumors has compared achievement on performance based measures to population norms. For examples, Mulhern and Kun (1985) found that 27% of the children in their sample had significant attention deficits following surgery and before radiation treatment. Only 15% of children were documented to have significant attention deficits six months following radiation and younger children were more susceptible to attention problems. More recent research indicates that core cognitive abilities such as attention are more likely to decline over time (Brière, Scott, McNall-Knapp, & Adams, 2008). Using the Conners’ Continuous Performance Test (CPT; Conners, 1992/1995), Reeves et al. (2006) found that children receiving treatment for brain tumors (i.e., medulloblastomas) scored significantly lower than standardization norms on eight of eleven CPT variables. Interestingly, children actually performed significantly better than norms on errors of commission suggesting that they were unwilling to take risks. Kiehna, Mulhern, Li, Xiong, and Merchant (2006) studied a group of children and young adults (i.e., 2 to 24 years) with brain tumors prospectively conducting their first assessment of attention prior to the onset of radiation. Prior to radiation, patients demonstrated mild inattentiveness but no problem with impulsivity, reaction time, or overall index scores. During radiation, there were no changes in inattentiveness, reaction time, or overall index scores, but impulsivity scores declined. Following treatment, inattention continued to increase. However, there were no changes in impulsivity, reaction time, or overall index scores. Outcomes were worse for those with surgical complications. These findings are consistent with other research suggesting that some children experience initial decreases in attention with continued decreases over time (Brière, et al., 2008).
Although most research has compared survivors’ performance to measure norms, some have included comparison groups. For example, Mabbott, Penkman, Witol, Strother, and Bouffet (2008) investigated sustained attention in a sample of children with posterior fossa tumors treated with surgery or a combination of surgery and radiation. In comparison to children with non-CNS cancer (and no CNS-directed treatment), there were no significant differences in sustained attention. However, as noted by the authors this finding may only hold true for children with posterior fossa tumors and not for other tumors that may have a greater impact on the anterior attention system. Interestingly, in a second study Mabbott, Snyder, Penkman, and Witol (2009) found that children with posterior fossa tumors did have impaired selective attention in comparison to non-CNS controls, demonstrating possible effects on the posterior attention systems.

Problems with attention are proposed to be directly influenced by treatment with combination therapy, particularly the contribution of radiation therapy, leading to the poorest outcomes (Dennis, Hetherington, & Spiegler, 1998; Mulhern & Butler, 2004). However, the impact of radiation on attention may be attenuated by lower doses of radiation (Mulhern, et al., 1998). Although diffuse and focal radiation may harm any number of areas within the brain, radiation is particularly harmful to white matter, and attention deficits in pediatric brain tumor survivors has been connected to white matter integrity. In a sample of children who had been treated for a brain tumor, Reddick et al. (2003) demonstrated that survivors’ attainment on a performance-based task of attention was worse than norms. Attention was significantly related to normal-appearing white matter, and attentional skills accounted for the association between normal-appearing white matter volume and full scale IQ scores. A similar relationship between attention
abilities and white matter volume in pediatric brain tumor survivors was found by Mulhern et al. (2004).

The potential impact of brain tumors and their treatment on surgency and negative affectivity is less clear. However, given the apparent biological underpinnings of temperament, it might be expected that these motivational systems could be affected. Brain tumors and their treatment are associated with adverse CNS functioning. This is especially true when more aggressive treatment regimens are used. In particular, focal and whole brain radiation appears to have the greatest impact on cognitive functioning (Mulhern & Butler, 2004). The potential harmful effects of treatment on the structural and neural underpinnings of surgency and negative affect should be considered. It should be noted, however, that this in no way implies that the biology of cognitive processes including attention, memory, or inferential abilities are similar to those underlying temperament. Nevertheless a brief summary of physiological structures involved with negative and positive affectivity follows (Kagan & Fox, 2006).

The defensive motivational system (i.e., negative affectivity or emotionality), and appetitive motivational system (i.e., positive affectivity, approach, activation, or surgency), involve similar and distinct structures. Each system also includes more primitive, evolutionary regions as well as more developed, complex regions. Defensive functions include those associated with “fight or flight” responses to fear implicating the brain stem. More complex defensive functions involve the limbic system and input processed via the cortex. The periaqueductal gray (PAG) has been implicated in the defensive system, and its components account, in part, for escape behavior, defensive aggression, and tonic immobility (Derryberry & Tucker, 2006). Also involved with this
system is the hypothalamus which allows better processing of distant dangers (Gray & McNaughton, 1996), the amygdala, which allows for conditioned fear responses (Gray, 1987), and the hippocampus, which allows for risk assessment (Derryberry & Tucker, 2006). Together, these four regions connect within the frontal lobe where cortical information can allow for a more sophisticated evaluation of threat (Derryberry & Tucker, 2006).

Like the defensive system there is evidence that biological structures (e.g., hippocampus and limbic system) involved in the appetitive motivational system include those which initiate goal-directed behavior for evolutionary adaptation, including sex, hunger, and thirst. Further, this system involves the reciprocal connections between the PAG, amygdala, and orbital and medial prefrontal networks (Derryberry & Tucker, 2006). What may be unique to the appetitive system is the role of dopamine and its involvement with the nucleus accumbens (Derryberry & Tucker, 2006). This system is involved in incentive motivation and goal-directed behavior, and impairments in this region lead to deficits in the initiation of volitional behavior (Depue & Collins, 1999).

The overall goal of the current study was to investigate the associations between aspects of temperament (i.e., effortful control, surgency, and negative affectivity) and patterns of social behaviors among children treated for brain tumors and comparison peers. Confirmatory analyses were run first to see if the current sample replicated findings from our larger sample such that children treated for brain tumors would be perceived as demonstrating fewer behaviors consistent with leadership and popularity, as well as aggressive or disruptive behavior, and more behaviors representing sensitivity and
isolation, as well as victimization. Subsequent analyses investigated the following aims and hypotheses as follows:

Aim 1: Examine differences in attention between children treated for a brain tumor and comparison peers.

   Hypothesis 1a: Children who have been treated for a brain tumor will demonstrate poorer functioning on performance-based measures of attention (i.e., attentional control/switching, sustained attention/response inhibition, and sustained attention) than comparison children.

Aim 2: Examine differences in both the broad construct of effortful control and its components between children treated for a brain tumor and comparison peers, including whether there are group differences in effortful control above and beyond group differences in attention.

   Hypothesis 2a: Children who have been treated for a brain tumor will demonstrate lower levels of effortful control, by parent and self-report, than comparison children.

   Hypothesis 2b: Children who have been treated for a brain tumor will demonstrate poorer performance in separate components of effortful control (i.e., attentional control, activation control, and inhibitory control) than comparison children.

   Hypothesis 2c: Group differences in effortful control will be partially mediated by or accounted for by group differences in attention.

Aim 3: Examine whether expected differences in social behavior between children treated for a brain tumor and comparison peers are accounted for by effortful control.
Hypothesis 3a: Effortful control (i.e., broad construct, as well as attentional control, activation control, and inhibitory control) will partially mediate or account for group differences in social behavior.

Aim 4: Explore differences in positive affect/surgency and negative affectivity between children treated for a brain tumor and comparison children.

Hypothesis 4a: Children who have been treated for a brain tumor will demonstrate less positive affect/surgency than comparison children.

Aim 5: Examine the interaction of surgency and negative affect with effortful control when accounting for variation in social behavior.

Hypothesis 5a: It is expected that surgency and negative affectivity will interact with effortful control such that sensitive-isolated behavior and victimization would be greatest when low levels of EC are combined with either high NA or low surgency.
Chapter 2: Method

Procedure

Following IRB approval, children diagnosed with a brain tumor were recruited for a study investigating the social and emotional functioning of children following treatment completion. Children were identified from the local tumor registries of two pediatric oncology centers and met the following inclusion criteria: (a) aged 8-15 years inclusive, (b) diagnosed and treated for a CNS malignancy located above the cervical spine, (c) off treatment for 1-5 years without current evidence of active disease, (d) without a pre-existing neurobehavioral disorder (e.g., neurofibromatosis or tubular sclerosis) and (e) residing within 100 miles of the medical center. Children were excluded if they: (a) were not fluent in English or (b) were home-schooled or received full-time special education.\(^1\)

Parents of children treated for a brain tumor received a letter from the child’s primary physician introducing the study. They were telephoned by study staff to obtain permission to collect data in the child’s classroom. After obtaining permission, a trained staff member contacted the child’s principal to describe the study and gain permission to coordinate data collection with the child’s teacher. If permission was granted, the staff member met with the child’s teacher to explain the study, obtain teacher consent and teacher reported data, and organize a time for classroom data collection. Teachers distributed consent forms to be taken home to all classmates including the target child.

\(^1\) Many self-contained special education classrooms have a small class size that may compromise the reliability and validity of the sociometric measures. However, children who received part-time special education services were included if they did not exclusively receive instruction in required academic subjects (e.g., English, math, social studies, science) in small, special education classes.
Only children with parental consent were allowed to participate in data collection. Classroom data were collected in the primary classroom of elementary school students or a required academic class for students in middle or high school. The students were met as a group in their classrooms by the staff member who had no contact with any of the children prior to administering the questionnaires. To ensure that the target child was not stigmatized and to reduce bias, the study was described as a project about children’s friendships with no mention of brain tumors, cancer, the medical center, or the ill child. Previous work with this method had demonstrated the children were unaware of the focus on any particular child when data were collected in the classroom (Noll, LeRoy, Bukowski, Rogosch, & Kulkarni, 1991). Approximately 85% of classmates had consent and participated in data collection. All students completed measures in a fixed order.

We used class rosters to identify one classmate of the same race, same gender, and closest date of birth for each child treated for a brain tumor to identify potential comparison children. Following school data collection, families of comparison children were invited to participate in the home based assessment. Families of potential comparison children were screened to ensure there had been no child in the family treated for a chronic medical condition. After completion of the home visit, families were invited to participate in a second assessment, also occurring in the family’s home. The study was described as a project investigating factors that could be related to children’s and adolescents’ social functioning. Parents completed a brief series of questionnaires (45 minutes). Children completed several questionnaires, were administered performance-based tasks, and were given tests targeting social-affective processes (2.5 hours). Children were offered a break half way through their assessment. The term “parents” in
the current project indicates a single, primary caregiver from each family. Families were compensated for their time.

Participants

Eighty six percent (N = 113 of 131) of parents with eligible children treated for a brain tumor gave permission to contact the child’s school. Data collection was successfully completed at 87% of these schools (N = 98). An initial home visit, which was not the focus of the current study, was completed with the families of 87 of the 98 brain tumor survivors (89%) for whom school data was collected. Families of 82 children treated for a brain tumor were eligible and contacted for the second home data collection and 75 (91%) participated. The final sample of brain tumor survivors for the current study was 57% (n = 43) male, 85% (n = 64) Caucasian, and had a mean age of 12.25 years (SD = 3.39 years). Children were 3.69 years from initial diagnosis (SD = 2.21 years) at study enrollment. Diagnoses included Astrocytoma (n = 35; 47%), Medulloblastoma (n = 17; 23%), and other brain tumors (n = 23; 30%). Ninety-one percent (n = 68) of the parents completing questionnaires were mothers and 9% (n = 7) were fathers.

Families of 84 comparison classmates were successfully recruited to complete the initial home visit. Eighty three comparison families were eligible and invited to participate in the second home data collection and 67 (81%) participated. This sample of comparison children was on average 12.25 years old (SD = 2.30), 55% (n = 43) male, and 87% (n = 58) Caucasian. In the comparison sample, 95% (n = 64) of the parents completing questionnaires were mothers and 5% (n = 3) were fathers. Of the comparison
families, 45% \( (n = 30) \) were first choices, and 24% \( (n = 16) \) were second choice, and 31% \( (n = 21) \) were or third or greater choices based on the date of birth.

**Measures**

*Classroom data collection*

*Revised Class Play* (RCP; Masten, Morison, & Pellegrini, 1985). This peer report measure of children’s patterns of behaviors and social interaction was completed in each classroom. The RCP asked students to imagine they are the director of a play and to “cast” their classmates into 42 hypothetical roles. Nominations were limited to students who were of the same gender as the target child to avoid sex-role stereotyping, and children were not permitted to nominate themselves.

Tallies of nominations received by each child for each role were computed. These item totals were converted to z scores, with a mean of zero and a standard deviation of one, within each class to adjust for uneven class sizes, composition, and participation rates. Four behavioral subscales: (a) Leadership-popularity (b) Prosocial, (c) Aggressive-disruptive, and (d) Sensitive-isolated, were created in accordance with recent factor analytic work (Zeller et al., 2003). Zeller et al. (2003) demonstrated a higher level of reliability for these four dimensions than the original three-factor structure (Masten et al., 1985) with a cross-age sample including students from elementary through high school. Reliability coefficients were .89 for Leadership-Popularity, .88-.89 for Aggressive-disruptive, .83-.88 for Sensitive-isolated, and .77-.85 for Prosocial (Zeller et al., 2003).

The primary difference in the factor structure suggested by Zeller et al. is the differentiation of a single dimension of positive social behavior into two distinct dimensions: (a) Leadership-popularity (e.g., a good leader, has many friends) and (b)
Prosocial (e.g. polite, helps others) behaviors. Three additional items were included to construct a Victimization subscale based on work by Crick (e.g., Crick & Nelson, 2002). In accordance with Masten’s original scoring recommendations, scale scores were created by summing the z scores for each of the roles loading on a behavioral dimension. These summed z scores were then standardized in order to adjust for unequal number of items on each scale. Given the variability of the number of items per scale, this procedure is beneficial in that it creates scale scores that have equivalent means and variances.

*Initial home data collection*

*Demographic Questionnaire* (Noll et al., 1999). This questionnaire was completed by parents to assess general background information about the family including parental marital status, socioeconomic status, and occupation. Socioeconomic status (SES) was computed using the Revised Duncan (TSEI), with scores ranging from 15.00 to 100.00 (Nakao & Treas, 1992).

*Second home data collection*

*The Test of Everyday Attention for Children (TEA-Ch)* (Manly et al., 1999). The TEA-Ch assesses different aspects of attention in children aged 6-16. Structural equation modeling supports a three-factor model of sustained attention, selective attention, and executive control that is congruent with widely cited models of attention. The TEA-Ch Walk/Don’t Walk subtest assesses sustained attention and inhibitory control. Children mark steps along a path each time they hear a tone, but they are not to do so if the tone is followed by a second sound. The rate of presentation of tones increases across 20 trials. A point is earned when the individual correctly avoids the target square (maximum 20 points). Raw scores are converted to scaled scores based on age and gender. In a
normative sample, this subscale avoided floor and ceiling effects for the full range of children age 6-16 (Manly, et al., 2001). Test-retest \((r = .73)\) is strong over 5-20 days. The TEA-Ch Code Transmission subtest assesses sustained attention and working memory. Similar to an auditory n-back test, children listen to a long, monotone series of numbers (presented at a rate of one every 2 seconds) for two “5”s in a row. When this is detected, they must state the number presented prior to the target “5”s. Following a practice sequence, 40 targets are presented over the 12 minute task. A point is earned for every correctly identified target number (maximum 40 points). Raw scores are converted to scaled scores based on age and gender. In a normative sample, this subscale avoided floor and ceiling effects for the full range of children age 6-16 (Manly, et al., 2001). Test-retest \((r = .82)\) is strong over 5-20 days. The TEA-Ch Creature Counting assesses mental flexibility and executive control. Children must repeatedly switch between counting forward and backward in response to visual target stimuli. Scoring takes into account the accuracy and children receive one point for correct responses (maximum 7 points). Raw scores are converted to scaled scores based on age and gender. In a normative sample, this subscale avoided ceiling effects for the full range of children age 6-16 (Manly, et al., 2001). Test-retest \((r = .73)\) was adequate over 5-20 days. It should be noted, however, that Verstraeten et al. (2010) did find ceiling effects for older children. The TEA-Ch subtests have been used in children and adolescents who have sustained neurological insults including those with traumatic brain injury (e.g., Catroppa, Anderson, Haritou, & Rosenfeld, 2006) and prefrontal lesions (Anderson, Jacobs, & Harvey, 2005). Cronbach’s alpha for the Tea-Ch composite, consisting of the three Tea-Ch subscales (i.e., Creature Counting, Walk, Don’t Walk, Code Transmission) was .60.
Early Adolescent Temperament Questionnaire-Revised (EATQ-R) (Capaldi & Rothbart, 1992; Ellis & Rothbart, 2001). This questionnaire assesses dimensions of temperament relevant to emotion regulation in children. This 62-item measure asks parents to rate child attitudes/behaviors on a 5-point Likert scale. Exploratory factor analyses of the EATQ-R has identified nine scales reflecting four temperament factors including: (a) Negative Affectivity (irritability, frustration), (b) Surgency (high intensity pleasure, low levels of shyness, low levels of fear), and (c) Effortful Control (attentional control, activation control, inhibitory control). The EATQ-R demonstrates good reliability, Cronbach’s alpha ranges from 65-.85. Cronbach’s alpha for the current sample were .83, .69, and .85 for Effortful Control, Surgency, and Negative Affect respectively. Cronbach’s alpha for the Effortful Control composite, consisting of the three EC subscales (i.e., attentional control, activation control, inhibitory control) was .79. The EATQ-R has been used in typically developing samples, children with ADHD (Martel & Nigg, 2006), and with children in relation to social behavior (Rothbart et al., 1994). The EATQ-R correlates with measures of anxiety and depression (e.g., Visser, Huizinga, Hoekstra, van der Graaf, Hoekstra-Weebers, 2007).

Effortful Control Scale (Lonigan & Phillips, 2001). This questionnaire is a 24-item measure that assesses child self-perceptions of self-regulatory abilities using a 5-point Likert scale. The resulting persistence/low distractibility subscale has been found to have good internal consistency (α = .85) and correlates with measures of anxiety and depression (e.g., Muris, 2006). Cronbach’s alpha for the current sample was .80.

Positive and Negative Affectivity Schedule (PANAS) (Watson, Clark, & Tellegen, 1988). This is a 27-item measure that asks children to rate the extent to which different
positive and negative feeling/emotion adjectives describe them on a 5-point scale ranging (1 = not at all to 5 = extremely). Items form negative affectivity (α = .84-.87) and positive affect (α = .86-.90) subscales. Cronbach’s alpha for positive affect and negative affect for the current sample were .88 and .91, respectively. This measure is included to provide child self-report of negative affectivity and positive affect/surgency.
Chapter 3: Analysis Plan

Data reduction

The current project included multiple indicators and multiple informants of attention, effortful control, positive affect/surgency, and negative affect. In an attempt to reduce the number of indicators for each analysis, Pearson correlations were run for multiple indicators of the same construct. The result of data aggregation is a more stable and unbiased estimator than any single measurement (Rushton, Brainerd, & Pressley, 1983). For example, in examining attention, the TEA-Ch Walk/Don’t Walk, Code Transmission, and Creature Counting scores were correlated with one another. If these measures of attention correlated at .3 or higher, the scaled scores were be averaged to derive a single indicator of attention. For effortful control, parent report of attentional control, activation control, and inhibitory control on the EATQ-R were correlated. If these three subscales of effortful control correlated with one another at .3 or higher, the broad measure of effortful control (derived from the three individual subscales) was to be used for regression analyses. For parent report of surgency and negative affectivity from the EATQ-R, only the measure of the broad constructs will be used in regression analyses to reduce multiple comparisons and Type I error.

There are several indicators in which both parent and child report is obtained. Pearson correlations were run to measure agreement between multiple reporters and if warranted, a composite or construct score should be created to reduce analyses and to create a more robust measure of that construct. For effortful control, the broad construct...
of effortful control from parent report (i.e., EATQ-R) and child report (i.e., EC scale) were correlated. If the resulting correlation was .3 or higher, a single indicator of effortful control was created by creating a standardized $z$ score of each indicator (to account for a different number of items for each reporter) and then averaging those two scores. For surgency, the broad construct of surgency from parent report (i.e., EATQ-R) and child report (i.e., PANAS) was correlated. If the resulting correlation was .3 or higher, a single indicator of surgency was created by creating a standardized $z$ score of each indicator (to account for a different number of items for each reporter) and then averaging those two scores. For negative affectivity, the broad construct of negative affectivity from parent report (i.e., EATQ-R) and child report (i.e., PANAS) were correlated. If the resulting correlation was .3 or higher, a single indicator of negative affectivity was created by creating a standardized $z$ score of each indicator (to account for a different number of items for each reporter) and then averaging those two scores. In the event that the strength of correlations between informants differed for the brain tumor and comparison groups, indicators would be examined separately for parents and children.

**Descriptive statistics**

Descriptive statistics were computed for demographic variables to describe the children and families in the brain tumor and comparison groups. Target and comparison children were initially matched for gender, age, and race with the intent of creating groups that were balanced, although not necessarily matched 1:1, for other demographic characteristics (e.g. family income, parental education or occupation). Two-tailed, independent $t$-tests ($\alpha < .05$) were used to examine group differences in demographic variables (i.e., child age, family SES). Prior to hypothesis testing, descriptive statistics
(e.g., mean, standard deviation, range, skew) were examined for the variables of interest (i.e., attention, temperament, social behavior).

**Confirmation of group differences in social behavior**

Prior to running analyses to examine the primary aims and hypotheses, differences were examined between children treated for brain tumors and comparison children on social behavior to confirm our prior findings with a larger sample. Thirty-three classrooms from the current sample were included in the prior sample, so they are partially overlapping samples. Two-tailed, independent t-tests ($\alpha < .05$) were run to examine group differences in the Sensitive-Isolated, Victimization, Leadership-Popularity, Prosocial, and Aggressive-Disruptive subscales of the RCP.

**Hypothesis testing**

To examine Aim 1, two-tailed, independent t-tests ($\alpha < .05$) were used to examine if children treated for a brain tumor demonstrated poorer performance on measures of attention (**Hypothesis 1a**). Differences in scaled scores on the Walk/Don’t Walk, Code Transmission, and Creature Counting subscales of the TEA-Ch were examined separately. Power for hypothesized tests was calculated with G*Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007). Based on a sample size of 142 (75 survivors, 67 comparison peers) we had an 99% likelihood of detecting effect sizes of .8. We had power of .91 to detect medium effect sizes ($d = .5$) for two-tailed tests with a significance at $p < .05$. However, power decreased to .55 to detect effect sizes of $d = .3$.

To examine Aim 2, two-tailed, independent t-tests ($\alpha < .05$) were used to examine if children treated for a brain tumor demonstrated lower levels of the broad construct of effortful control than comparison children (**Hypothesis 2a**). Separate t-tests examined the
broad construct of effortful control from the EATQ-R (parent report) and the persistence/low distractibility scale from the EC scale (child report). Next, two-tailed, independent t-tests ($\alpha < .05$) were used to examine if children treated for a brain tumor demonstrated poorer performance in all components of effortful control than comparison children (Hypothesis 2b). This analysis was run using the three components of effortful control (i.e., attentional control, activation control, and inhibitory control) from the EATQ-R (parent report).

Also within Aim 2, analyses examined whether group differences in effortful control were at least partially accounted for by attention (Figure 1) (Hypothesis 2c). Hierarchical regression examined the extent to which group differences in effortful control were attenuated when the TEA-Ch subscale was included in the predictive model. In Step 1 of each regression, the predictor (brain tumor vs. comparison group) was entered. In Step 2 of each regression, the mediator (attention) was entered. Post-hoc tests were conducted using bootstrapping procedures (Preacher & Hayes, 2004) to test the significance of indirect effects. Bootstrapping is considered a more powerful method to test for indirect effects because it makes no assumption about the shape of the distributions of the variables or the sampling distribution of the statistic (Preacher & Hayes, 2004). It also can be applied to small samples (e.g., <200) with more confidence than other indirect effect probing techniques (e.g., Sobel test). Using bootstrapping, the indirect effect is estimated based on a large number of bootstrap samples generated from the data by random sampling with replacement. If the 95% confidence interval for the estimates of the indirect effect does not include zero, mediation is considered significant at $\alpha < .05$. 

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Within Aim 3, analyses examined whether group differences in social behavior were at least partially accounted for by effortful control (Figure 2) \textbf{(Hypothesis 3a)}. A hierarchical regression model predicting each social behavior subscale was run to examine changes in beta for the predictor (i.e., brain tumor vs. comparison group) with and without the appropriate EC indicator in the model. A hierarchical regression model examined the regression weight assigned to the predictor (group) without and with the mediator in the model. In Step 1 of each regression, the predictor (brain tumor vs. comparison group) was entered. In Step 2 of each regression, the mediator (effortful control) was entered. Post-hoc tests were conducted using bootstrapping procedures (Preacher & Hayes, 2004).

To examine Aim 4, two-tailed, independent $t$-tests ($\alpha < .05$) were used to examine if children treated for a brain tumor differed from comparison children in negative affect and surgency. Differences between the groups were examined separately for parent report of surgency (EATQ-R Surgency) and child report of positive affect/surgency (PANAS Positive Affect/Surgency), as well as parent report of negative affect (EATQ-R Negative Affect) and child report of negative affect (PANAS Negative Affect). Power for hypothesized tests was calculated with G*Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007). Based on a sample size of 142 (75 survivors, 67 comparison peers) we had an 99\% likelihood of detecting effect sizes of .8. We had power of .91 to detect medium effect sizes ($d = .5$) for two-tailed tests with a significance at $p < .05$. However, power decreased to .55 to detect effect sizes of $d = .3$.

Within Aim 5, analyses examined whether effortful control interacted with positive affect/surgency (Figure 3) or negative affect (Figure 4) to account for variation in social
behavior. Analyses investigated whether the effect of effortful control on social behavior was particularly salient when combined with high NA or low positive affect/surgency (i.e., hypothesized conditional indirect effects). In other words, analyses examined whether the mediator of interest (e.g., effortful control) was conditional on the value of a moderator (e.g., positive affect/surgency or negative affect). In accordance with recommendations by Preacher, Rucker, and Hayes (2007), these regressions were conducted whether or not the mediating effect of effortful control was found (i.e., Aim 3). Regressions with bootstrapping were run according to the procedures and SPSS macro described by provided by Preacher and colleagues (2007).
Chapter 4: Results

Data reduction

Multiple indicators and multiple informants of attention, effortful control, positive affect/surgency, and negative affect were measured. In an attempt to reduce the number of indicators for each hypothesized model, Pearson correlations were computed to examine congruence among indicators for each construct both within measures and between reporting sources (see Table 1). Correlations between the TEA-Ch attention subtests scaled scores (i.e., Walk/Don’t Walk, Code Transmission, and Creature Counting) subtests were .29-.39. As a result, a single indicator of attention was created for analyses examining Hypothesis 2c by averaging across the three scores for each participant. This single indicator of attention was created to develop a more robust measure of attention that may more likely represent the broad construct of executive functioning of interest in this project.

Associations between effortful control subscales within and across sources were examined. Correlations between the EATQ-R effortful control subscales (i.e., attentional control, activation control, and inhibitory control) were .43-.71. As a result, a single indicator of parent reported effortful control was be created by following the EATQ-R authors’ recommendations for combining the subscale scores (Ellis & Rothbart, 2001). This single indicator was used for analyses examining hypotheses 2a, 2c, 3a, and 5a. Parent and child agreement on temperament variables was not high and therefore the
model involving these variables was tested twice (once with child report and once with parent report).

**Descriptive statistics**

Independent *t*-tests and chi-square analyses were conducted to examine group differences in demographic and background variables (see Table 2 and Table 3). Children in the two groups did not differ significantly with regards to age, race, ethnicity, or gender. Families of pediatric brain tumor survivors were characterized by lower SES, as indicated by less occupational prestige, than comparison families. Families did not significantly differ in income or number of parents in the home.

Skewness and kurtosis statistics were run on all variables of interest (i.e., attention, temperament, and social behavior). Values for skewness were between -.98 and 1.75, well within the recommended limits of +3 (Glasnap & Poggio, 1985). Values for kurtosis were between -.78 and 2.93, also within the recommended limits of +3 (Maxwell & Delaney, 2004).

**Confirmatory analyses: Group differences in social behavior**

Group differences in peer reported social behavior were examined with independent *t*-tests (see Table 4). Pediatric brain tumor survivors were perceived by their classmates as demonstrating fewer behaviors consistent with Leadership-popularity than comparison peers. Survivors were rated higher on scales assessing levels of Sensitivite-isolated behavior and Victimization. Survivors and comparison peers did not differ on scales measure Prosocial or Aggressive-Disruptive behavior.

**Aims 1 and 2: Group differences in attention and effortful control and examination of attention as a mediator of group differences in effortful control**
Group differences in attention and effortful control were examined with independent t-tests. Consistent with hypotheses, pediatric brain tumor survivors demonstrated worse performance on tasks measuring attention and were rated by parents as demonstrating less effortful control than comparison peers (see Table 5). With regards to attention, survivors scored lower on TEA-Ch Code Transmission as well as the averaged TEA-Ch attention variable. There was a trend in the same direction for performance on the TEA-Ch Walk, Don’t Walk subtest. Parents rated survivors as lower on effortful control subscales measuring attention and activation. Parents also rated survivors as lower than comparison peers on the broad measure of effortful control. Survivors and comparison peers did not differ in self-report of effortful control.

Given the overlapping nature of attention and effortful control, it was expected that group differences in effortful control would be, in part, accounted for by attention skills. Hierarchical regression with bootstrapping was run to examine this model separately for parent and child report of effortful control (see Table 6). Analyses indicated that attention did not mediate group differences in effortful control according to child report as the bootstrapping confidence interval included zero (-.02 to .09). Attention did mediate group differences in effortful control according to parent report as indicated by the bootstrapping confidence interval which did not include zero (.01 to .18), indicating that attention performance does account, at least in part, for differences in parent perception of effortful control for brain tumor survivors and comparison peers.

Aim 3: Mediation of group differences in social behavior

A series of hierarchical regression analyses were conducted to examine if effortful control mediated the association between group (i.e., survivor or comparison) and peer
reported social behavior (see Table 7). These analyses were run separately for child report and parent report of effortful control and for each of the five social behavior subscales. Post-hoc analyses were examined using bootstrapping. Despite the fact that an independent group t-test had not identified a significant difference in Prosocial behavior for brain tumor survivors and comparison peers, regression results indicated that parent reported effortful control mediated an association between group and prosocial behavior (i.e. the bootstrapping confidence interval did not include zero). Mediation was not significant for other models.

**Aim 4: Group differences in affectivity**

Group differences in positive affect/surgency and negative affect were examined with independent t-tests individually for child and parent report (see Table 8). Survivors of pediatric brain tumors were reported to demonstrate lower positive affect/surgency according to self and parent report. There were no group differences in negative affect.

**Aim 5: Examination of affectivity as moderating the mediating role of effortful control on the group effect on social behavior**

Moderated-mediation analyses were conducted to explore whether the mediation models conducted in Aim 3 varied depending on the level of positive affect/surgency or negative affect reported for children (Tables 9 and 10). Analyses indicated that effortful control mediated the association between group (brain tumor vs. comparison) and prosocial behavior for moderate or high levels of parent reported surgency, but not for low levels of surgency (Figure 5). Effortful control was also found to mediate the association between group and aggressive-disruptive behavior at moderate or high levels of parent reported surgency, but not at low levels of surgency (Figure 6).
Moderated-mediation analyses also indicated effortful control mediated the association between group (brain tumor vs. comparison) and prosocial behavior for moderate or low levels of parent reported negative affect, but not for high levels of negative affect (Figure 7). Effortful control was found to mediate the association between group and aggressive-disruptive behavior for moderate or low levels of negative affect, but not high levels of negative affect (Figure 8).
Chapter 5: Discussion

While research has documented that children treated for a brain tumor experience problematic social outcomes, specific deficits and the nature of this phenomena are not well understood. The current study was developed to investigate the nature of children’s social behavior post-treatment as well as to provide a possible explanation for this behavior. Utilizing contemporary models of social information processing as a framework, the influence of treatment for a brain tumor was examined in relation to children’s emotion and behavior regulation and reactivity within their social environment. By including a comparison group comprised of peers matched for gender, race, and age, we examined group differences in effortful control, positive affect/surgency, and negative affect between pediatric brain tumor survivors and children not treated for a chronic illness. We also examined the influence of these constructs on children’s social behavior. Previous findings regarding group differences in social behavior were replicated in the current sample and differences were found for some, but not all, measures of attention, effortful control, and affectivity. Effortful control did not consistently account for group differences in social behavior. However, temperament did have some utility in predicting social behavior for some subscales on the RCP.

As expected, we found that pediatric brain tumor survivors differed from peers in social behavior (Vannatta et al., under review). Survivors were viewed by peers as demonstrating fewer behaviors consistent with leadership and popularity than comparison peers. Survivors were also rated higher than peers on sensitivity and social
isolation as well as victimization by peers. Unlike prior findings, group differences in aggressive and disruptive behavior did not reach significance, although analyses indicated a trend with survivors being rated lower on this scale than comparison peers. This result may be due to the fact that the sample in the current study was nearly half the size of the sample in our prior study, making it more difficult to obtain significance. On the other hand, the effect size of differences in aggressive and disruptive behavior in the larger sample was -.56, while it was smaller (-.26) in the current sample and may reflect actual differences between the two samples.

The primary goal of this study was to further understand these differences in social behavior by examining potential explanatory variables drawn from contemporary temperament models. Traditionally, temperament has been understood as individual differences which are present from birth and relatively stable across time. However, given the biological underpinnings of temperament (Derryberry & Tucker, 2006), it is possible that an individual’s temperament may be impacted following neurological insult. By using a group of matched comparison peers, the current study investigated the possibility that temperament may be altered when children are treated for a CNS tumor. Group differences in effortful control, surgency/positive affect, and negative affect were examined.

It was hypothesized that survivors would demonstrate less effortful control, or capacity to regulate emotion and behavior through initiation or constraint, and that this may provide some explanation for their resulting social behavior. To our knowledge effortful control has not been previously studied in children treated for a brain tumor. Our hypothesis was based on the well documented finding that treatment for a brain tumor
during childhood has detrimental effects on attention (Brière, et al., 2008), and attention and effortful control are overlapping constructs. Survivors were rated by parents as lower on effortful control than comparison children. In addition, survivors demonstrated worse attention skills than comparison children on performance based tasks. As expected, attention at least partially accounted for parent reported differences in effortful control, supporting the overlapping nature of these constructs.

Although group differences in effortful control were hypothesized given that group differences in attention were expected, it was less clear how survivors would be rated on measures of positive affect/surgency and negative affect. Given evidence of behavior consistent with sensitivity and isolation, it was hypothesized that positive affect/surgency would be lower in survivors potentially indicating less interest or motivation to engage in the environment (Rothbart, 2007). No specific hypotheses regarding negative affect were made. Consistent with expectations, survivors were lower in positive affect/surgency than comparison peers according to both parent and self-report. No significant differences in negative affect were identified by either parent or self-report, however analyses indicated a trend suggesting that survivors may perceive themselves as higher in negative affect than comparison peers. Taken together, group differences in effortful control, positive affect/surgency, and a trend for differences in negative affect suggest that affectivity, like effortful control, may be altered by pediatric brain tumor treatment. That is, the relative stability of these constructs may be disrupted by neurological insult during childhood.

A strength of the current study was the use of multiple informants of temperament. Many studies of psychosocial outcomes among children rely on parent
report of indicators of the child’s functioning. This study considered the perspectives of both parents and children within the two groups (i.e., brain tumor and comparison peers), allowing some insight into the pattern of results based on reporter. The pattern of significant and non-significant differences between the groups for positive affect/surgency and negative affect suggest that children and parents may demonstrate some agreement on these indicators of temperament, even when not using parallel forms. Interestingly, self-report of effortful control did not vary between groups although parent report did suggest group differences. Also, in contrast to parent ratings, self-report of effortful control was not associated with performance on attention tasks. Given the corroboration of parent report of effortful control with a performance based task of attention, it is possible that children may not accurately report effortful control or self-regulatory skills.

It was hypothesized that effortful control would mediate group differences in social behavior, and that mediation would depend upon (i.e., be moderated by) the child’s level of positive affect/surgency and negative affect (i.e., moderated-mediation). Interestingly, mediation was found for the RCP subscales measuring prosocial and aggressive and disruptive behavior, the only scales in which brain tumor survivors and comparison peers did not differ. Mediation was dependent upon level of positive affect/surgency and negative affect. That is, effortful control only mediated group differences in these social behavior subscales when children were at high levels of positive affect/surgency and low levels of negative affect. The interactions within these findings are consistent with prior research which supports the notion that a deficit in self-
regulation (i.e., effortful control) is most detrimental when this deficit coincides with particular levels of affectivity.

Effortful control mediated group differences in prosocial and aggressive and disruptive behavior when surgency was at moderate or high levels. These results suggest that deficits in effortful control are only problematic, that is they lead to less prosocial or more aggressive-disruptive behavior, when children also demonstrate high levels of surgency. These findings are consistent with other research. Children who are dysregulated and have high levels of surgency are perceived as being aggressive (Gunnar et al., 2003), demonstrating social dominance (Hawley, 2002), and having more externalizing behaviors (Berden, et al., 2008). Considerably less research has examined surgency in relation to prosocial behavior, however one might expect that high surgency may predict less prosocial behavior as it predicts other negative social outcomes including being less well liked by peers (Berden et al., 2008).

While significant group differences in aggressive and disruptive behavior were not identified, it should be noted that there was a trend for survivors to demonstrate less aggressive and disruptive behavior than peers and, in fact, this finding reached significance in our larger study. An interpretation of this finding indicates that effortful control may account for modest differences in aggressive-disruptive behavior when children demonstrate moderate to high levels of surgency. Although children treated for brain tumors may be dysregulated in comparison to peers, they are actually less likely to be perceived as aggressive or disruptive because they do not have the second “requirement” for this behavior, high levels of surgency. In other words, it is possible that
low levels of surgency may actually serve a unique role in protecting survivors from becoming aggressive or disruptive.

Effortful control mediated group differences in prosocial and aggressive and disruptive behavior when negative affect was at low levels. That is, deficits in effortful control appeared to only lead to less prosocial and more aggressive and disruptive behavior when children also demonstrate low levels of negative affect. These associations are contradictory. It would be expected that less prosocial behavior would more likely be predicted by high levels of negative affect because children would be more likely to be withdrawn, irritable, and avoidant of social interaction. In fact, children high in negative emotionality, a construct overlapping with negative affect, have been found to demonstrate less socially appropriate behavior (Sallquist, et al., 2009). Similarly, greater aggressive and disruptive social behavior would likely be predicted by high, not low, levels of negative affect given its association with irritability.

This project did not find evidence that temperament (i.e., effortful control, negative affect, positive affect/surgency) aided in explaining group differences in social behavior. Although this data is cross-sectional, behaviors reflecting leadership and popularity, sensitivity and isolation, and victimization appear to be strongly affected by treatment for a brain tumor. However effortful control was not found to mediate these differences. Similarly, positive affect/surgency and negative affect were also not found to contribute to the prediction of these behaviors. These findings are somewhat contradictory to what would be expected from theories of temperament, as well as previous literature which has identified links between temperament and broad social outcomes, including indices of social behavior.
From a theoretical perspective, I hypothesized that poor effortful control would have a detrimental influence on social behavior by limiting a child’s ability to initiate positive social behaviors or constrain negative social behaviors during social interaction. Effortful control is particularly important in its interaction with positive affect/surgency and negative affect. In examining these constructs in relation to our measures of social behavior, some patterns were expected. It was expected that the Sensitive-Isolated subscale of the RCP would be associated with poor effortful control, particularly when children exhibit low levels of positive affect/surgency and high levels of negative affect. These children would be expected to be less likely to engage in approach behaviors and more likely exhibit avoidance. The behavioral result of these temperamental tendencies is supported by prior research on shy children (Findlay, Coplan, & Bowker, 2009), avoidant children (Coplan, et al., 2006), socially withdrawn children (Booth-LaForce & Oxford, 2008), and infants demonstrating social wariness (Henderson et al., 2001). Interestingly while the brain tumor survivors in our sample were found to be less self-regulated and lower in positive affect/surgency than comparison peers, the interaction of these temperamental constructs did not predict sensitive and isolated behavior as would be expected from theory and developmental literature.

Past research has found that children who are dysregulated are more likely to be victimized, and we hypothesized that poor effortful control would account for greater victimization in our brain tumor sample. Victimization during childhood and adolescence has been associated with emotion dysregulation (McLaughlin, Hatzenbuehler, & Hilt, 2009) and an indicator of dysregulation capturing self-regulation and high negative affect (Pope & Bierman, 1999). Children who are dysregulated and high in positive
affect/surgency are also at risk for victimization as they are more likely to be aggressive which leads to rejection (Gunnar, et al., 2008). Children high in positive affect/surgency have also been found to be less well liked by peers, putting them at risk for victimization (Berden, et al., 2008), whereas children with high self-regulation are better well-liked (Buckner, et al., 2009). Our sample of brain tumor survivors, while dysregulated, were perceived as being lower in positive/affect surgency than peers suggesting that their path to victimization may differ from that of healthy children.

The final RCP subscale in which we did not find evidence of mediation was Leadership-popularity. It may be expected that behaviors associated with this subscale would most likely be evident for children with good self-regulatory abilities as well as those who are high in positive affect/surgency (e.g., approach behavior) and possibly low negative affect (e.g., avoidant/withdrawn behavior). In fact, children with low negative emotionality were viewed as having more socially appropriate behavior and being more sociable (including popularity) in one study (Eisenberg et al., 1995). Parker-Cohen and Bell (1988) found that children with higher positive affect/surgency were also more sociable. Although brain tumor survivors in our sample were less regulated and demonstrated low levels of positive affect, this did not appear to account for less leadership and popularity.

The results of this study should be considered within the context of its limitations and statistical considerations. First are limitations regarding our sample characteristics. Although our sample size was larger than most pediatric brain tumor outcome studies, a larger sample size would have increased power and potentially allowed for detection of significant effects where we found trends (e.g., aggressive-disruptive behavior, negative
affect). Our sample size also limited our ability to consider the potential influence of treatment (i.e., radiation, chemotherapy, surgery, or combined treatment), illness (e.g., tumor type and location, time since treatment) or demographic (e.g., age, gender) factors. For example, examination of gender and age may be warranted as there is evidence that children treated at younger age (Reimers et al., 2003) and females (Brown et al., 1998; Waber, Tarbell, Kahn, Gelber, & Sallan, 1992) are at greatest risk for neurocognitive deficits following CNS-directed treatment. Similarly, children receiving higher doses of radiation are also more likely to demonstrate neurocognitive deficits (Mulhern et al., 1998). As such, it may be expected that these subgroups may have more dramatic changes in temperament. Additionally, parent report of temperament variables was provided by a combination of mothers and fathers, although the group consisted of primarily mothers. Ideally, we would have had all available mothers and fathers participate in this project so that we might be able to create a latent score which may have been a more robust measure of these constructs.

The cross-sectional nature of this study also somewhat limits our conclusions. This study was based, in part, on the notion that temperament would change as a result of a childhood brain tumor and its treatment. Due to a lack of prospective data, we were unable to track a potential change in temperament and resulting changes in social behavior over time. Timing of data collection should also be considered in regards to statistical constraints. It has been recommended that when utilizing meditational analyses, the mediator should precede the outcome in time (Baron & Kenny, 1986). For the current study, peer reported social behavior was collected prior to temperament data, potentially further limiting our ability to draw causal inferences. Another potential statistical
limitation is the use of positive affect/surgency as a moderator. While this application was in alignment with theories of temperament, it may not have followed assumptions of moderation. In our sample, these variables were predicated by group (i.e., brain tumor versus comparison). According to traditional moderation models, it is preferable that the moderator be unrelated to the predictor in order to provide the most interpretable interaction term (Baron & Kenny, 1986). Finally, enrollment criteria for the current study required that pediatric brain tumor survivor be in at least one main-streamed classroom, which indicates that this sample does not include the most impaired survivors. Thus, the results of this study may not be applicable to all survivors.

Despite these limitations, this project has several strengths to be noted. First, while the sample size was not large, it was larger than most studies investigating psychosocial outcomes in pediatric brain tumor survivors (Fuemmeler et al., 2002). We were also able to examine the temperament and social behavior of survivors relative to matched comparison peers. Another strength of this project was the use of multiple informants. Ratings of social behavior were provided by all peers within a child’s classroom, creating a more reliable measure of children’s behavior than using a single informant alone. Furthermore, the collection of both parent and self-report of temperament, allowed us to consider their unique perspectives. Finally, while our sample was primarily White, non-Hispanic, data collection at multiple sites may better represent different geographic regions.

Overall, the current project makes a significant contribution to what is understood about psychosocial outcomes for pediatric brain tumor survivors. First, we documented that a behavioral correlate of executive functioning, effortful control, may be affected by
pediatric brain tumors and their treatment suggesting a decrease in self-regulatory capacities which could lead to behavioral deficits in both restraint and initiation. Furthermore, we identified less surgency and potentially more negative affect in survivors than comparison peers, and that these aspects of temperament appeared to interact with effortful control in influencing social behavior. Not only is this information helpful in furthering our knowledge for social outcomes of these children, the documentation of temperament differences in survivors may also be helpful in explaining emotional functioning in survivors as theories of temperament posit the utility of predicting internalizing and externalizing disorders.

While this study was developed to provide a possible explanation for differences in social behavior among pediatric brain tumor survivors, we actually found that these temperament variables were most helpful in explaining where group differences in social behavior were less likely to be observed. This may indicate that changes in temperament do not play a large role in children’s social behavior following treatment for a brain tumor. Future work should continue to consider other aspects of social information processing models in identifying factors that may influence social behavior and social outcomes for pediatric brain tumor survivors. For example, models may take into consideration other constructs that may be affected by neurological insult including affect recognition, social problem solving, or pragmatic language skills. Identification of such variables may aid in the development of interventions to promote positive social relationships and improve overall quality of life for survivors.

Replication of these findings is necessary, as this is the first investigation of temperament in children and adolescents treated for brain tumors. This is particularly
important to determine if trends indicating differences in negative affect exist in similar samples. Additionally, given that we found evidence of significant moderated-mediation that contradicts what is expected from theory and prior research, it is important to consider these models in other samples. If findings are similar, it may imply that the addition of other potential mediating and moderating variables is warranted. Finally, future work should collect data prospectively. Ideally, data would be collected on children’s temperament and social behavior at diagnosis, prior to treatment, and during survivorship. By using longitudinal methods, researchers will be better equipped to examine changes in temperament and social behavior over time, as well as to determine the value of temperament in predicting such changes. Work may also consider applying these models to children sustaining neurological deficits from other causes.

Clinically, those working with children and families who have gone through the experience of treatment for a brain tumor should take into consideration the psychosocial effects of treatment. It is unclear if the changes in temperament can be altered. However, there is evidence that interventions such as cognitive remediation have shown improvements in children’s attention skills. In fact, this has been demonstrated in children following treatment for cancer. Butler and Copeland (2002) found that children treated for cancer demonstrated significant improvement on sustained attention after participating in a cognitive remediation intervention which included repetitive computerized training exercises, training in meta-cognitive strategies, and cognitive-behavioral intervention coupled with parent and teacher involvement. Others have found that methylphenidate may improve attention in survivors (Conklin, et al., 2010). The
improvement in attentional skills suggests that there may be some improvement in effortful control, given the overlapping nature of these constructs.

Clinicians should consider how changes in temperament may influence people in the child’s life. Both anecdotally and qualitatively, parents have expressed how their child seems “different” following treatment (Vance, Eiser, & Horne, 2004). Assisting parents in processing these changes and developing an understanding or expectation of these changes may be helpful, particularly because family processes may moderate the extent to which neurocognitive impact may influence psychosocial outcomes (Patel & Carlson-Green, 2005). Similarly, it may be helpful to provide information to teachers about why the child is less regulated and less outgoing. Providing both parents and teachers with tools to encourage social interaction may help increase their sense of control as well as the child’s social well being.


system malignancies in the Childhood Cancer Survivor Study. *Journal of the National Cancer Institute, 13*, 946-958.


for acute lymphocytic leukemia receiving chemotherapy as CNS prophylaxis.


Vannatta, K., et al. (under review). Social behavior and peer acceptance of pediatric brain tumor survivors relative to peers: Results of the Brain Tumor Survivor Friendship Study.


Appendix A: Tables and Figures
Table 1. Correlations among variables with multiple indicators and multiple informants (N = 142)

<table>
<thead>
<tr>
<th></th>
<th>TEA-Ch CC</th>
<th>TEA-Ch WDW</th>
<th>TEA-Ch CT</th>
<th>ECS P/LD</th>
<th>EATQ-R EC</th>
<th>EATQ-R Act</th>
<th>EATQ-R Att</th>
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** p < .01, *** p < .001

*Note.* TEA-Ch Average = mean of TEA-Ch Creature Counting, TEA-Ch Walk Don’t Walk, TEA-Ch Code Transmission; TEA-Ch WDW = TEA-Ch Walk, Don’t Walk; TEA-Ch CT = TEA-Ch Code Transmission; ECS P/LD = Effortful Control Scale, Persistence/Low Distractibility subscale; EATQ-R EC = EATQ-R Effortful Control; EATQ-R Act = EATQ-R Activation Control; EATQ-R Att = EATQ-R Attention Control; EATQ-R Inh = EATQ-R Inhibitory Control; PA = PANAS Positive Affect; NA = PANAS Negative Affect; EATQ-R PA = EATQ-R Surgency/PA; EATQ-R NA = EATQ-R Negative Affect.
Table 1 continued

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** p < .01, *** p < .001

Note. TEA-Ch Average = mean of TEA-Ch Creature Counting, TEA-Ch Walk Don’t Walk, TEA-Ch Code Transmission; TEA-Ch WDW = TEA-Ch Walk, Don’t Walk; TEA-Ch CT = TEA-Ch Code Transmission; ECS = Effortful Control Scale; EATQ-R EC = EATQ-R Effortful Control; EATQ-R Act = EATQ-R Activation Control; EATQ-R Att = EATQ-R Attention Control; EATQ-R Inh = EATQ-R Inhibitory Control; PA = PANAS Positive Affect; NA = PANAS Negative Affect; EATQ-R PA = EATQ-R Surgency/PA; EATQ-R NA = EATQ-R Negative Affect.
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<th>Brain Tumor</th>
<th>Comparison</th>
<th>t&lt;sup&gt;a&lt;/sup&gt;</th>
<th>P</th>
<th>d&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Age</td>
<td>12.28 ± 2.39</td>
<td>12.25 ± 2.30</td>
<td>.07</td>
<td>.95</td>
<td>.01</td>
</tr>
<tr>
<td>Family Income</td>
<td>59,500 ± 41,700</td>
<td>73,200 ± 47,800</td>
<td>-1.82</td>
<td>.07</td>
<td>-.31</td>
</tr>
<tr>
<td>Occupational</td>
<td>52.21 ± 22.21</td>
<td>59.43 ± 20.75</td>
<td>-1.99*</td>
<td>.05</td>
<td>-.34</td>
</tr>
<tr>
<td>Prestige</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Degrees of Freedom = 140. <sup>b</sup>Effect sizes represented with Cohen’s $d$.

* $p < .05$


Table 2. Group differences in demographic variables
<table>
<thead>
<tr>
<th>Demographic Characteristic</th>
<th>Brain Tumor $n$ (%)</th>
<th>Comparison $n$ (%)</th>
<th>X$^2$</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child’s Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caucasian</td>
<td>64 (85%)</td>
<td>58 (87%)</td>
<td>1.72</td>
<td>.42</td>
</tr>
<tr>
<td>African-American</td>
<td>7 (10%)</td>
<td>8 (12%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>4 (5%)</td>
<td>1 (1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child’s Ethnicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>2 (3%)</td>
<td>1 (1%)</td>
<td>.24</td>
<td>.63</td>
</tr>
<tr>
<td>Non Hispanic</td>
<td>73 (97%)</td>
<td>64 (99%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td># Parents in Household</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 parent home</td>
<td>24 (32%)</td>
<td>13 (19%)</td>
<td>2.92</td>
<td>.09</td>
</tr>
<tr>
<td>2 parent home</td>
<td>51 (68%)</td>
<td>54 (81%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>43 (57%)</td>
<td>37 (55%)</td>
<td>.12</td>
<td>.73</td>
</tr>
<tr>
<td>Female</td>
<td>32 (43%)</td>
<td>30 (45%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Group differences in demographic variables analyzed with chi-square analyses
<table>
<thead>
<tr>
<th>RCPc Subscale</th>
<th>Brain Tumor $M \pm SD$</th>
<th>Comparison $M \pm SD$</th>
<th>$t^a$</th>
<th>$d^b$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership-</td>
<td>-.41 ± .75</td>
<td>.29 ± .98</td>
<td>-4.76***</td>
<td>-.81</td>
<td>.00</td>
</tr>
<tr>
<td>Popularity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prosocial</td>
<td>.11 ± .90</td>
<td>.18 ± .96</td>
<td>-.46</td>
<td>-.08</td>
<td>.65</td>
</tr>
<tr>
<td>Aggressive-</td>
<td>-.24 ± .80</td>
<td>.00 ± .99</td>
<td>-1.55</td>
<td>-.26</td>
<td>.12</td>
</tr>
<tr>
<td>Disruptive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitive-Isolated</td>
<td>.67 ± 1.10</td>
<td>-.13 ± .89</td>
<td>4.71***</td>
<td>.80</td>
<td>.00</td>
</tr>
<tr>
<td>Victimization</td>
<td>.49 ± 1.20</td>
<td>-.04 ± .91</td>
<td>2.92**</td>
<td>.74</td>
<td>.00</td>
</tr>
</tbody>
</table>

*a* Degrees of Freedom = 138. *b* Effect sizes represented with Cohen’s $d$.

** $p < .01$, *** $p < .001$

*Note.* RCP = Revised Class Play completed by classroom peers.

Table 4. Group differences in social behavior
<table>
<thead>
<tr>
<th>Variable</th>
<th>Brain Tumor $M \pm SD$</th>
<th>Comparison $M \pm SD$</th>
<th>$t^a$</th>
<th>$d^b$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEA-Ch Average</td>
<td>7.93 ± 2.83</td>
<td>9.00 ± 2.42</td>
<td>-2.39*</td>
<td>-.40</td>
<td>.02</td>
</tr>
<tr>
<td>TEA-Ch CC</td>
<td>8.56 ± 3.53</td>
<td>9.41 ± 3.00</td>
<td>-1.52</td>
<td>-.26</td>
<td>.13</td>
</tr>
<tr>
<td>TEA-Ch WDW</td>
<td>6.49 ± 4.15</td>
<td>7.72 ± 3.81</td>
<td>-1.79</td>
<td>-.31</td>
<td>.08</td>
</tr>
<tr>
<td>TEA-Ch CT</td>
<td>8.65 ± 3.72</td>
<td>9.83 ± 3.12</td>
<td>-2.00*</td>
<td>-.34</td>
<td>.05</td>
</tr>
<tr>
<td>ECS</td>
<td>3.89 ± .70</td>
<td>4.04 ± .55</td>
<td>-1.36</td>
<td>-.23</td>
<td>.18</td>
</tr>
<tr>
<td>EATQ-R EC</td>
<td>3.17 ± .60</td>
<td>3.41 ± .56</td>
<td>-2.53*</td>
<td>-.43</td>
<td>.01</td>
</tr>
<tr>
<td>EATQ-R Act</td>
<td>3.02 ± .64</td>
<td>3.25 ± .62</td>
<td>-2.14*</td>
<td>-.64</td>
<td>.03</td>
</tr>
<tr>
<td>EATQ-R Att</td>
<td>2.87 ± .72</td>
<td>3.37 ± .70</td>
<td>-4.12**</td>
<td>-.69</td>
<td>.00</td>
</tr>
<tr>
<td>EATQ-R Inh</td>
<td>3.63 ± .78</td>
<td>3.65 ± .63</td>
<td>-.16</td>
<td>-.03</td>
<td>.87</td>
</tr>
</tbody>
</table>

$^a$Degrees of Freedom = 134-140. $^b$Effect sizes represented with Cohen’s $d$.  
** $p < .01$, *** $p < .001$

*Note.* TEA-Ch Average = mean of TEA-Ch Creature Counting, TEA-Ch Walk Don’t Walk, TEA-Ch Code Transmission; TEA-Ch WDW = TEA-Ch Walk, Don’t Walk; TEA-Ch CT = TEA-Ch Code Transmission; ECS = Effortful Control Scale; EATQ-R EC = EATQ-R Effortful Control; EATQ-R Act = EATQ-R Activation Control; EATQ-R Att = EATQ-R Attention Control; EATQ-R Inh = EATQ-R Inhibitory Control.

Table 5. Group differences in attention and effortful control
Table 6. Hierarchical regression and bootstrapping examining attention as a mediator of group differences in effortful control

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>$R$</th>
<th>$\Delta R^2$</th>
<th>Step</th>
<th>Predictor</th>
<th>Beta$^a$</th>
<th>Bootstrapping confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECS</td>
<td>.12</td>
<td>.02</td>
<td>1</td>
<td>Group</td>
<td>.12</td>
<td>-.02 to .09</td>
</tr>
<tr>
<td></td>
<td>.16</td>
<td>.01</td>
<td>2</td>
<td>Group</td>
<td>.10</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TEA-Ch</td>
<td>.11</td>
<td></td>
</tr>
<tr>
<td>EATQ-R EC</td>
<td>.20</td>
<td>.04*</td>
<td>1</td>
<td>Group</td>
<td>.20*</td>
<td>.01 to .18</td>
</tr>
<tr>
<td></td>
<td>.42</td>
<td>.13***</td>
<td>2</td>
<td>Group</td>
<td>.13***</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TEA-Ch</td>
<td>.37***</td>
<td></td>
</tr>
</tbody>
</table>

$^a$Standardized beta weight

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

Note. ECS = Child report of effortful control; EATQ-R EC = Parent report of effortful control. TEA-Ch = TEA-Ch Average score. Group = Brain tumor survivors vs. comparison peers.
<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>$R$</th>
<th>$\Delta R^2$</th>
<th>Step</th>
<th>Predictor</th>
<th>Beta&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Bootstrapping 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCP Subscale</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leadership-Popularity</td>
<td>.40</td>
<td>.16</td>
<td>1</td>
<td>Group</td>
<td>.40***</td>
<td>-.03 to .06</td>
</tr>
<tr>
<td></td>
<td>.40</td>
<td>.00</td>
<td>2</td>
<td>Group</td>
<td>.39***</td>
<td></td>
</tr>
<tr>
<td>Leadership-Popularity</td>
<td>.38</td>
<td>.14</td>
<td>1</td>
<td>Group</td>
<td>.38***</td>
<td>-.02 to .13</td>
</tr>
<tr>
<td></td>
<td>.38</td>
<td>.01</td>
<td>2</td>
<td>Group</td>
<td>.36***</td>
<td></td>
</tr>
<tr>
<td>Prosocial</td>
<td>.05</td>
<td>.00</td>
<td>1</td>
<td>Group</td>
<td>.05</td>
<td>-.02 to .12</td>
</tr>
<tr>
<td></td>
<td>.20</td>
<td>.04</td>
<td>2</td>
<td>Group</td>
<td>.03</td>
<td></td>
</tr>
<tr>
<td>Prosocial</td>
<td>.04</td>
<td>.00</td>
<td>1</td>
<td>Group</td>
<td>.04</td>
<td>.03 to .27</td>
</tr>
<tr>
<td></td>
<td>.32</td>
<td>.1</td>
<td>2</td>
<td>Group</td>
<td>-.03</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Standardized beta weight  
* $p < .05$, ** $p < .01$, *** $p < .001$

*Note.* RCP = Revised Class Play; ECS = Child report of effortful control; EATQ-R EC = Parent report of effortful control.

Table 7. Hierarchical regression and bootstrapping examining effortful control as a mediator of group differences in social behavior
### Table 7 continued

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>$R$</th>
<th>$\Delta R^2$</th>
<th>Step</th>
<th>Predictor</th>
<th>Beta$^a$</th>
<th>Bootstrapping 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCP Subscale</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggressive-Disruptive</td>
<td>.13</td>
<td>.02</td>
<td>1</td>
<td>Group</td>
<td>.13</td>
<td>-.11 to .02</td>
</tr>
<tr>
<td></td>
<td>.19</td>
<td>.02</td>
<td>2</td>
<td>Group</td>
<td>.14</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ECS</td>
<td>-.14</td>
<td></td>
</tr>
<tr>
<td>Aggressive-Disruptive</td>
<td>.13</td>
<td>.02</td>
<td>1</td>
<td>Group</td>
<td>.13</td>
<td>-.27 to -.03</td>
</tr>
<tr>
<td></td>
<td>.35</td>
<td>.11</td>
<td>2</td>
<td>Group</td>
<td>.20*</td>
<td>-.33***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>EATQ-R EC</td>
<td>-.33***</td>
<td></td>
</tr>
<tr>
<td>Sensitive-Isolated</td>
<td>.38</td>
<td>.15</td>
<td>1</td>
<td>Group</td>
<td>-.38***</td>
<td>-.07 to .05</td>
</tr>
<tr>
<td></td>
<td>.38</td>
<td>.00</td>
<td>2</td>
<td>Group</td>
<td>-.38***</td>
<td>-.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ECS</td>
<td>-.02</td>
<td></td>
</tr>
<tr>
<td>Sensitive-Isolated</td>
<td>.37</td>
<td>.14</td>
<td>1</td>
<td>Group</td>
<td>-.37***</td>
<td>-.13 to .03</td>
</tr>
<tr>
<td></td>
<td>.38</td>
<td>.01</td>
<td>2</td>
<td>Group</td>
<td>-.36***</td>
<td>-.07</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>EATQ-R EC</td>
<td>-.07</td>
<td></td>
</tr>
</tbody>
</table>

$^a$Standardized beta weight  
* $p < .05$, ** $p < .01$, *** $p < .001$

**Note.** RCP = Revised Class Play; ECS = Child report of effortful control; EATQ-R EC = Parent report of effortful control.
Table 7 continued

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>R</th>
<th>$\Delta R^2$</th>
<th>Step</th>
<th>Predictor</th>
<th>Beta&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Bootstrapping 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCP Subscale</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Victimization</td>
<td>.25</td>
<td>.06</td>
<td>1</td>
<td>Group</td>
<td>-.25**</td>
<td>-.08 to .04</td>
</tr>
<tr>
<td></td>
<td>.27</td>
<td>.00</td>
<td>2</td>
<td>Group</td>
<td>-.25**</td>
<td>-.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ECS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Victimization</td>
<td>.24</td>
<td>.06</td>
<td>1</td>
<td>Group</td>
<td>-.24**</td>
<td>-.19 to .01</td>
</tr>
<tr>
<td></td>
<td>.28</td>
<td>.02</td>
<td>2</td>
<td>Group</td>
<td>-.21*</td>
<td>-.14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>EATQ-R EC</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Standardized beta weight

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

<sup>Note</sup>. RCP = Revised Class Play; ECS = Child report of effortful control; EATQ-R EC = Parent report of effortful control.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Brain Tumor $M \pm SD$</th>
<th>Comparison $M \pm SD$</th>
<th>$t^a$</th>
<th>$d^b$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>PANAS Positive Affect</td>
<td>3.61 ± .79</td>
<td>3.99 ± .64</td>
<td>-3.15**</td>
<td>-.53</td>
<td>.00</td>
</tr>
<tr>
<td>PANAS Negative Affect</td>
<td>1.90 ± .74</td>
<td>1.71 ± .71</td>
<td>1.59</td>
<td>.27</td>
<td>.12</td>
</tr>
<tr>
<td>EATQ-R Surgency</td>
<td>3.05 ± .45</td>
<td>3.23 ± .45</td>
<td>-2.33*</td>
<td>-.39</td>
<td>.02</td>
</tr>
<tr>
<td>EATQ-R Negative Affect</td>
<td>2.67 ± .63</td>
<td>2.54 ± .61</td>
<td>1.25</td>
<td>.21</td>
<td>.21</td>
</tr>
</tbody>
</table>

$^a$Degrees of Freedom = 139-140.

$^* p < .05$, $^{**} p < .01$, $^{***} p < .001$

*Note. PANAS = Child report; EATQ-R = Parent report.*

Table 8. Group differences in positive affect/surgency and negative affect
<table>
<thead>
<tr>
<th>RCP Subscale</th>
<th>Reporter</th>
<th>Level of Positive Affect/Surgency</th>
<th>Indirect Path</th>
<th>SE</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership-Popularity</td>
<td>Child</td>
<td>-0.97</td>
<td>0.01</td>
<td>0.03</td>
<td>0.27</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
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<td>0.02</td>
<td>0.00</td>
<td>0.02</td>
<td>0.18</td>
<td>0.86</td>
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<td>0.00</td>
<td>0.03</td>
<td>-0.01</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td>Parent</td>
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<td>0.08</td>
<td>0.05</td>
<td>1.46</td>
<td>0.14</td>
</tr>
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<td>0.04</td>
<td>0.04</td>
<td>0.99</td>
<td>0.32</td>
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<td></td>
<td>1.01</td>
<td>0.00</td>
<td>0.04</td>
<td>-0.10</td>
<td>0.92</td>
</tr>
<tr>
<td>Prosocial</td>
<td>Child</td>
<td>-0.97</td>
<td>0.04</td>
<td>0.04</td>
<td>0.90</td>
<td>0.37</td>
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<td>0.02</td>
<td>0.04</td>
<td>0.04</td>
<td>1.10</td>
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<td>0.05</td>
<td>0.05</td>
<td>0.94</td>
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<tr>
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<td>Parent</td>
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<td>0.13</td>
<td>0.08</td>
<td>1.75</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.00</td>
<td>0.13</td>
<td>0.06</td>
<td>2.09</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.01</td>
<td>0.13</td>
<td>0.06</td>
<td>2.12</td>
<td>0.03</td>
</tr>
<tr>
<td>Aggressive-Disruptive</td>
<td>Child</td>
<td>-0.97</td>
<td>-0.03</td>
<td>0.04</td>
<td>-0.85</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
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<td>0.02</td>
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Table 9. Bootstrapping estimates of the indirect path (Group \(\rightarrow\) Effortful control \(\rightarrow\) Social Behavior) at varying levels of positive affect/surgency using standardized predictors
Table 9 continued

<table>
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<tr>
<th>RCP Subscale</th>
<th>Reporter</th>
<th>Level of Positive Affect/Surgency</th>
<th>Indirect Path</th>
<th>SE</th>
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<td>Sensitive-Isolated</td>
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<td>Indirect Path</td>
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Table 10. Bootstrapping estimates of the indirect path (Group → Effortful control → Social Behavior) at varying levels of negative affect using standardized predictors
Table 10 continued

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<tr>
<th>RCP Subscale</th>
<th>Reporter</th>
<th>Level of Negative Affect</th>
<th>Indirect Path</th>
<th>SE</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitive-Isolated</td>
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Note. aGroup = brain tumor survivors vs. comparison peers; bAttention = TEA-Ch subtests (Walk/Don’t Walk, Creature Counting, Code Transmission); cEffortful Control = EATQ-R effortful control construct, EATQ-R attentional control subscale, EATQ-R activation control subscale, EATQ-R inhibitory control construct, ECS child report of persistence/low distractibility
TEA-Ch = Test of Everyday Attention for Children
EATQ-R = Early Adolescent Temperament Questionnaire – Revised
ECS = Effortful Control Scale

Figure 1. Model of hypothesis that attention would, in part, account for group differences in effortful control. Regressions were run separately for all variables for each indicator.
Figure 2. Model of hypothesis that effortful control would account for group differences in social behavior. Regressions were run separately for all variables for each indicator.

Note. aGroup = brain tumor survivors vs. comparison peers; bEffortful Control = EATQ-R effortful control construct, EATQ-R attentional control subscale, EATQ-R activation control subscale, EATQ-R inhibitory control construct, ECS child report of persistence/low distractibility; cSocial Behavior = RCP Leadership-popularity scale, RCP Prosocial scale, RCP Aggressive-disruptive scale, RCP Sensitive-isolated scale, RCP Victimization scale

EATQ-R = Early Adolescent Temperament Questionnaire – Revised
ECS = Effortful Control Scale
RCP = Revised Class Play
Group\(^a\) → Effortful Control\(^b\) → Surgency\(^d\) → Social Behavior\(^c\)

*Note.* \(^a\)Group = brain tumor survivors vs. comparison peers; \(^b\)Effortful Control = EATQ-R effortful control construct, EATQ-R attentional control subscale, EATQ-R activation control subscale, EATQ-R inhibitory control construct, ECS child report of persistence/low distractibility; \(^c\)Social Behavior = RCP Leadership-popularity scale, RCP Prosocial scale, RCP Aggressive-disruptive scale, RCP Sensitive-isolated scale, RCP Victimization scale; \(^d\)Surgency = EATQ-R Surgency, PANAS Surgency/Positive Affect

EATQ-R = Early Adolescent Temperament Questionnaire – Revised
ECS = Effortful Control Scale
RCP = Revised Class Play
PANAS = Positive and Negative Affectivity Schedule

Figure 3. Model of hypothesis that surgency would interact with effortful control in predicting group differences in social behavior. Regressions were run separately for all variables for each indicator.
Note. aGroup = brain tumor survivors vs. comparison peers; bEffortful Control = EATQ-R effortful control construct, EATQ-R attentional control subscale, EATQ-R activation control subscale, EATQ-R inhibitory control construct, ECS child report of persistence/low distractibility; cSocial Behavior = RCP Leadership-popularity scale, RCP Prosocial scale, RCP Aggressive-disruptive scale, RCP Sensitive-isolated scale, RCP Victimization scale; dNegative Affect = EATQ-R Negative Affect, PANAS Negative Affect
EATQ-R = Early Adolescent Temperament Questionnaire – Revised
ECS = Effortful Control Scale
RCP = Revised Class Play
PANAS = Positive and Negative Affectivity Schedule

Figure 4. Model of hypothesis that negative affect would interact with effortful control in predicting group differences in social behavior. Regressions were run separately for all variables for each indicator.
Model when Surgency$^d$ is at -2 SD

\[
\text{Group}^a \rightarrow \text{Effortful Control}^b \rightarrow \text{Prosocial}^c
\]

Model when Surgency$^d$ is at -1 SD

\[
\text{Group}^a \rightarrow \text{Effortful Control}^b \rightarrow \text{Prosocial}^c
\]

Model when Surgency$^d$ is at the mean*

\[
\text{Group}^a \rightarrow \text{Effortful Control}^b \rightarrow \text{Prosocial}^c
\]

Model when Surgency$^d$ is at +1 SD*

\[
\text{Group}^a \rightarrow \text{Effortful Control}^b \rightarrow \text{Prosocial}^c
\]

Model when Surgency$^d$ is at +2 SD

\[
\text{Group}^a \rightarrow \text{Effortful Control}^b \rightarrow \text{Prosocial}^c
\]

$^a$Group = brain tumor survivors vs. comparison peers; $^b$Effortful Control = EATQ-R effortful control construct (parent report); $^c$Prosocial = RCP Peer report of prosocial behavior; $^d$Surgency = EATQ-R Surgency

*Indicates significant moderated-mediation.

Note. Figure notes the effect of the predictor on the mediator and the effect of the mediator on the outcome at the mean, +/- 1, and +/- 2 standard deviations of the moderator.

Figure 5. Models of effortful control mediating the association between group and Prosocial behavior at levels of surgency.
Model when Surgency\(^d\) is at -2 SD

\[
\begin{align*}
\text{Group}\(^a\) & \rightarrow .43 \rightarrow \text{Effortful Control}\(^b\) \rightarrow -.08 \rightarrow \text{Aggressive-disruptive}\(^c\) \\
\end{align*}
\]

Model when Surgency\(^d\) is at -1 SD

\[
\begin{align*}
\text{Group}\(^a\) & \rightarrow .43 \rightarrow \text{Effortful Control}\(^b\) \rightarrow -.19 \rightarrow \text{Aggressive-disruptive}\(^c\) \\
\end{align*}
\]

Model when Surgency\(^d\) is at the mean\(^*\)

\[
\begin{align*}
\text{Group}\(^a\) & \rightarrow .43 \rightarrow \text{Effortful Control}\(^b\) \rightarrow -.31 \rightarrow \text{Aggressive-disruptive}\(^c\) \\
\end{align*}
\]

Model when Surgency\(^d\) is at +1 SD\(^*\)

\[
\begin{align*}
\text{Group}\(^a\) & \rightarrow .43 \rightarrow \text{Effortful Control}\(^b\) \rightarrow -.43 \rightarrow \text{Aggressive-disruptive}\(^c\) \\
\end{align*}
\]

Model when Surgency\(^d\) is at +2 SD\(^*\)

\[
\begin{align*}
\text{Group}\(^a\) & \rightarrow .43 \rightarrow \text{Effortful Control}\(^b\) \rightarrow -.54 \rightarrow \text{Aggressive-disruptive}\(^c\) \\
\end{align*}
\]

\(^a\)Group = brain tumor survivors vs. comparison peers; \(^b\)Effortful Control = EATQ-R effortful control construct (parent report), \(^c\)Aggressive-disruptive = RCP Peer report of aggressive-disruptive behavior; \(^d\)Surgency = EATQ-R Surgency

*Indicates significant moderated-mediation.

**Note.** Figure notes the effect of the predictor on the mediator and the effect of the mediator on the outcome at the mean, +/- 1, and +/- 2 standard deviations of the moderator.

Figure 6. Models of effortful control mediating the association between group and Aggressive-disruptive behavior at levels of surgency
Model when Negative Affect\textsuperscript{d} is at -2 SD\textsuperscript{*}

\begin{center}
\begin{tikzpicture}
\node[rectangle] (group) at (0,0) {Group\textsuperscript{a}}; 
\node[rectangle] (effortful) at (3,0) {Effortful Control\textsuperscript{b}}; 
\node[rectangle] (prosocial) at (6,0) {Prosocial\textsuperscript{c}}; 
\node at (1.5,.5) {\textbf{.43}}; 
\node at (4.5,.5) {\textbf{.63}}; 
\node at (3.8,-.5) {\textbf{.43}}; 
\node at (5.8,-.5) {\textbf{.43}}; 
\node at (6.3,-.5) {\textbf{.43}}; 
\draw[->,black] (group) -- (effortful); 
\draw[->,black] (effortful) -- (prosocial); 
\end{tikzpicture}
\end{center}

Model when Negative Affect\textsuperscript{d} is at -1 SD\textsuperscript{*}

\begin{center}
\begin{tikzpicture}
\node[rectangle] (group) at (0,0) {Group\textsuperscript{a}}; 
\node[rectangle] (effortful) at (3,0) {Effortful Control\textsuperscript{b}}; 
\node[rectangle] (prosocial) at (6,0) {Prosocial\textsuperscript{c}}; 
\node at (1.5,.5) {\textbf{.43}}; 
\node at (4.5,.5) {\textbf{.43}}; 
\node at (3.8,-.5) {\textbf{.43}}; 
\node at (5.8,-.5) {\textbf{.43}}; 
\node at (6.3,-.5) {\textbf{.43}}; 
\draw[->,black] (group) -- (effortful); 
\draw[->,black] (effortful) -- (prosocial); 
\end{tikzpicture}
\end{center}

Model when Negative Affect\textsuperscript{d} is at the mean\textsuperscript{*}

\begin{center}
\begin{tikzpicture}
\node[rectangle] (group) at (0,0) {Group\textsuperscript{a}}; 
\node[rectangle] (effortful) at (3,0) {Effortful Control\textsuperscript{b}}; 
\node[rectangle] (prosocial) at (6,0) {Prosocial\textsuperscript{c}}; 
\node at (1.5,.5) {\textbf{.43}}; 
\node at (4.5,.5) {\textbf{.24}}; 
\node at (3.8,-.5) {\textbf{.43}}; 
\node at (5.8,-.5) {\textbf{.43}}; 
\node at (6.3,-.5) {\textbf{.43}}; 
\draw[->,black] (group) -- (effortful); 
\draw[->,black] (effortful) -- (prosocial); 
\end{tikzpicture}
\end{center}

Model when Negative Affect\textsuperscript{d} is at +1 SD\textsuperscript{*}

\begin{center}
\begin{tikzpicture}
\node[rectangle] (group) at (0,0) {Group\textsuperscript{a}}; 
\node[rectangle] (effortful) at (3,0) {Effortful Control\textsuperscript{b}}; 
\node[rectangle] (prosocial) at (6,0) {Prosocial\textsuperscript{c}}; 
\node at (1.5,.5) {\textbf{.43}}; 
\node at (4.5,.5) {\textbf{.05}}; 
\node at (3.8,-.5) {\textbf{.43}}; 
\node at (5.8,-.5) {\textbf{.43}}; 
\node at (6.3,-.5) {\textbf{.43}}; 
\draw[->,black] (group) -- (effortful); 
\draw[->,black] (effortful) -- (prosocial); 
\end{tikzpicture}
\end{center}

Model when Negative Affect\textsuperscript{d} is at +2 SD

\begin{center}
\begin{tikzpicture}
\node[rectangle] (group) at (0,0) {Group\textsuperscript{a}}; 
\node[rectangle] (effortful) at (3,0) {Effortful Control\textsuperscript{b}}; 
\node[rectangle] (prosocial) at (6,0) {Prosocial\textsuperscript{c}}; 
\node at (1.5,.5) {\textbf{.43}}; 
\node at (4.5,.5) {\textbf{-.18}}; 
\node at (3.8,-.5) {\textbf{.43}}; 
\node at (5.8,-.5) {\textbf{.43}}; 
\node at (6.3,-.5) {\textbf{.43}}; 
\draw[->,black] (group) -- (effortful); 
\draw[->,black] (effortful) -- (prosocial); 
\end{tikzpicture}
\end{center}

\textsuperscript{a}Group = brain tumor survivors vs. comparison peers; \textsuperscript{b}Effortful Control = EATQ-R effortful control construct (parent report); \textsuperscript{c}Prosocial = RCP Peer report of prosocial behavior \textsuperscript{d}Negative Affect = EATQ-R Negative Affect 

\textsuperscript{*}Indicates significant moderated-mediation.

\textit{Note.} Figure notes the effect of the predictor on the mediator and the effect of the mediator on the outcome at the mean, +/- 1, and +/- 2 standard deviations of the moderator.

Figure 7. Models of effortful control mediating the association between group and Prosocial behavior at levels of negative affect
Model when Negative Affect\textsuperscript{d} is at -2 SD

\[ \begin{array}{ccc}
\text{Group}^a & \rightarrow & \text{Effortful Control}\textsuperscript{b} & \rightarrow & \text{Aggressive-disruptive}\textsuperscript{c} \\
.43 & & -.48 & & \\
\end{array} \]

Model when Negative Affect\textsuperscript{d} is at -1 SD*

\[ \begin{array}{ccc}
\text{Group}^a & \rightarrow & \text{Effortful Control}\textsuperscript{b} & \rightarrow & \text{Aggressive-disruptive}\textsuperscript{c} \\
.43 & & -.39 & & \\
\end{array} \]

Model when Negative Affect\textsuperscript{d} is at the mean*

\[ \begin{array}{ccc}
\text{Group}^a & \rightarrow & \text{Effortful Control}\textsuperscript{b} & \rightarrow & \text{Aggressive-disruptive}\textsuperscript{c} \\
.43 & & -.31 & & \\
\end{array} \]

Model when Negative Affect\textsuperscript{d} is at +1 SD

\[ \begin{array}{ccc}
\text{Group}^a & \rightarrow & \text{Effortful Control}\textsuperscript{b} & \rightarrow & \text{Aggressive-disruptive}\textsuperscript{c} \\
.43 & & -.24 & & \\
\end{array} \]

Model when Negative Affect\textsuperscript{d} is at +2 SD

\[ \begin{array}{ccc}
\text{Group}^a & \rightarrow & \text{Effortful Control}\textsuperscript{b} & \rightarrow & \text{Aggressive-disruptive}\textsuperscript{c} \\
.43 & & -.14 & & \\
\end{array} \]

\textsuperscript{a}Group = brain tumor survivors vs. comparison peers; \textsuperscript{b}Effortful Control = EATQ-R effortful control construct (parent report); \textsuperscript{c}Aggressive-disruptive = RCP Peer report of aggressive-disruptive behavior; \textsuperscript{d}Negative Affect = EATQ-R Negative Affect

*Indicates significant moderated-mediation.

\textit{Note.} Figure notes the effect of the predictor on the mediator and the effect of the mediator on the outcome at the mean, +/- 1, and +/- 2 standard deviations of the moderator.

Figure 8. Models of effortful control mediating the association between group and Aggressive-disruptive behavior at levels of negative affect