Social Functioning in Survivors of Pediatric Cancer:

A Conceptual Model of Assessment

by

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Dissertation submitted in partial fulfillment of
the requirements for the degree of Doctor of Philosophy in the Department of
Psychology and Neuroscience in the Graduate School
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ABSTRACT

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# Abstract

Many survivors of pediatric brain tumors and leukemia will experience cognitive, academic, and social difficulties that will significantly impact their quality of life. Of these, the least is known about the nature and range of survivors' social difficulties. Using a model developed for children with traumatic brain injury, the objective of the current study was to evaluate the neurocognitive and social-cognitive skills that may determine social outcomes in survivors of pediatric brain tumors and leukemia. A sample of survivors of childhood cancer aged 8 to 16 (n = 19) was compared to two control groups – children with ADHD (n = 10) and typically-developing children (n = 41) – on measures of neurocognitive skills, social-cognitive skills, and social experience. Results revealed that survivors demonstrated significant deficits in all domains as compared to typically-developing children. Evaluation of the model revealed that neurocognitive and social-cognitive skills were significant predictors of social experience. More specifically, attention problems and facial expression recognition were significant individual predictors. Survivors of pediatric cancer may experience deficits in social functioning that will impact their quality of life. Further assessment of the skills that influence social outcomes will be particularly important as a means for developing evidence-based interventions.

# Dedication

This work is dedicated to my family, friends and colleagues who every day push me to be better.

This work is also dedicated to the patients and their families who always said "yes."

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## Acknowledgements

This dissertation would not have been possible without the support and effort of many individuals. First, I would like to thank my parents, family and friends, and particularly "the corner": all of whom provide support, editing, sanity and love at every turn.

Second, I owe a sincere debt of gratitude to the Pediatric Psychology Lab, a group that has been my second home for the last six years. First, to Taryn Allen, who dove in head first when I needed her the most, and who was me when I was not there. Second, to Kristi Hardy, who was always ready with advice or a laugh. Her passion and wealth of ideas are an invaluable source of support and knowledge. Finally, to Melanie Bonner, who took a chance on me when I was newly graduated from college and wide-eyed, with little idea of what I was getting myself into. Her tireless enthusiasm, compassion, and availability are hallmarks of what any advisor should be, and I consider myself lucky to know her.

I am sincerely thankful for the undergraduate research assistants that have supported this research over the last couple of years. I am particularly grateful to Sarah Hostetter and Lucy Andrzjejwski for their tireless efforts in data collection and data entry and for their passion for learning about pediatric psychology.

I would also like to thank my committee (Dr Melanie Bonner, Dr John Curry, Dr David Rabiner and Dr Sri Gururangan) for reading and providing feedback on my proposal and final draft. I am grateful for the wisdom they never hesitate to share.

A special note of thanks to my father who has been my editor from the time I learned to write, and who provided comments on the final draft even as he was halfway

across the world. I will always be grateful for his unwavering support as I became the "next Dr. Willard."

Finally, my dissertation could not have been completed without the participants: to the families, patients, and children who agreed to spend several hours completing tests, questionnaires, and looking at faces, thank you.

# 1. Introduction

A significant portion of survivors of childhood cancer whose disease affects the central nervous system will experience cognitive, academic, and social difficulties, which collectively limit their *quality of survival* well into adulthood. Indeed, the cognitive and social consequences of surviving pediatric cancer, while variable, are potentially devastating. Symptoms including diminished IQ and academic failure can underlie reduced achievement of major developmental milestones such as graduating from college, living independently, obtaining stable employment, and marrying (see Butler & Haser, 2006; Gurney et al., 2009; Moore, 2005; Mulhern & Palmer, 2003 for recent reviews). Among a range of cognitive, academic, and interactive problems, the least is known about the nature and range of survivors' social problems. Given this, the objective of the current study was to gain a more comprehensive understanding of the range of social functioning deficits experienced by survivors of pediatric cancer.

The limited understanding of survivors' social deficits remains a significant gap in current knowledge and is often attributed to a lack of detailed studies and the use of insensitive measures (e.g., Barakat et al., 2003; Bonner et al., 2008). To overcome this gap will require systematic study and may be best achieved by following the example set by research completed with groups of children who have similar deficits to survivors of pediatric cancer; one such well-studied group is children with traumatic brain injuries (Penkman, 2004; Poggi et al., 2005). Like survivors of central nervous system-impacting cancer, children with traumatic brain injury experience a brain injury and subsequent cognitive impairments that influence their social functioning (Levin, Hanten, & Li, 2009). As such, their range of deficits is markedly similar to that of survivors, and they represent a strong example to follow. Based on decades of research, models have been developed for children with traumatic brain injury that delineate the major components of social functioning (Yeates et al., 2007). Specifically, such models have focused on the

evaluation of the skills that determine social outcomes, rather than focusing on the assessment of general social adjustment that has made up the crux of research in survivors thus far (Fuemmeler, Elkin, & Mullins, 2002).

This focus on skills among affected children provides a potential basis for the eventual development of evidence-based interventions that will impact social functioning and ultimately improve quality of life among the cancer survivor cohort examined here. Therefore, by applying the lessons that have come from previous research, the aim of the current paper is to increase understanding of social functioning in survivors of central nervous system-impacting cancer through the assessment of the skills that determine social outcomes.

## *1.1 Childhood Cancer: Incidence and Impact*

The two most common forms of childhood cancer – brain tumors and acute lymphoblastic leukemia (ALL) – account for over half of all new diagnoses annually (American Cancer Society, 2011). Both diagnoses affect the central nervous system (CNS) and thus may have the most significant impact on quality of life (Dickerman, 2007). Pediatric brain tumors are a solid tumor of which there are numerous types, including medulloblastoma, ependymoma, and pilocytic astrocytoma (CBTRUS, 2008). ALL, on the other hand, is a cancer of the white blood cells that starts in the bone marrow and then spreads to the bloodstream, and possibly the CNS as well (American Cancer Society, 2011). While ALL is typically treated with a three-year course of chemotherapy and, for some children, with low doses of either cranial-spinal or total body radiation, brain tumors are treated with a combination of surgery, chemotherapy and higher doses of cranial-spinal radiation (Keating, Goodrich, & Packer, 2001). Survival rates are estimated at about 85-90% for ALL (American Cancer Society, 2011),

and about 65% across brain tumor types, with some tumor types significantly lower and others significantly higher, depending on tumor grade and location (CBTRUS, 2008).

"Late effects" are the medical, physical, cognitive and psychosocial sequelae associated with cancer and its treatments that generally emerge two to five years after treatment ends (see Landier & Bhatia, 2008 for a recent review). Cognitive deficits are the most prevalent late effects faced by survivors of CNS-impacting cancers, with data suggesting that about 30% of survivors of ALL and 40 to 100% of survivors of pediatric brain tumors will suffer some degree of impairment, including deficits in attention, working memory, and processing speed, as well as visual-motor integration and nonverbal reasoning (Bisen-Hersh, Hineline, & Walker, 2011; Campbell et al., 2007; Mulhern & Palmer, 2003; Robinson et al., 2010).

For survivors of pediatric brain tumors in particular, such deficits weigh heavily on their academic performance, with survivors unable to learn new information at the same rate as their healthy peers, putting them at risk for academic failure. Given the acute impact these deficits have on academic performance, as well as the future impact on survivors' ability to gain employment, research efforts have focused on describing the nature and range of these cognitive deficits (see Bonner, Hardy, Willard, & Gururangan, 2009; Brière, Scott, McNall-Knapp, & Adams, 2008; Butler & Haser, 2006; Palmer, Reddick, & Gajjar, 2007 for examples), as well as on providing a preliminary understanding of the underlying neurological insults that may account for these deficits (e.g., damage to white matter and to folate pathways) (Kamdar et al., 2011; Krull et al., 2008; Mabbott, Noseworthy, Bouffet, Rockel, & Laughlin, 2006; Reddick et al., 2003).

Investigators also have begun to design evidence-based interventions in an attempt to ameliorate some of these deficits (Butler, Sahler, et al., 2008). Preliminary efficacy has been found for several modes of intervention, including the use of psychostimulant medications (Conklin, Helton, et al., 2010; Mulhern et al., 2004; S. J. Thompson et al., 2001), several types of cognitive remediation (Butler, Copeland, et al.,

2008; Kesler, Lacayo, & Booil, 2011; Patel, Katz, Richardson, Rimmer, & Kilian, 2009), and computerized cognitive training (Hardy, Willard, & Bonner, 2011). Further, it has been suggested that by intervening earlier, perhaps while children are undergoing active treatment, we may be able to prevent or reduce some deficits (Askins & Moore, 2008). With such significant progress made in the understanding of cognitive deficits in survivors, as well as initial efforts made towards their amelioration, attention can now be turned to other areas that significantly impact survivors' quality of life, including social functioning.

## *1.2 Social Functioning in Survivors of Pediatric Cancer*

Traditionally, research efforts aimed at understanding social functioning in children with cancer have focused on the impact of school absenteeism and reduced exposure to peers (E. R. Katz & Varni, 1993; Noll et al., 1999). However, once treatment protocols were adjusted to allow children to return to school earlier and more frequently, it was observed that some degree of impairment in social functioning still remained. Unfortunately, subsequent research has typically focused on children without primary-CNS disease, thereby excluding survivors with brain tumors. As such, published reports suggest that survivors experience largely normal social functioning (Manne & Miller, 1998; Newby, Brown, Pawletko, Gold, & Whitt, 2000; Noll et al., 1997; Patenaude & Kupst, 2005), with longer-term data showing normal rates of attainment of adult milestones (e.g., marrying, living independently, etc.) (Crom et al., 2007; Gerhardt, Vannatta, Valerius, Correll, & Noll, 2007; Zebrack et al., 2002). However, by excluding children with brain tumors, these studies were unable to evaluate those with the highest risk for brain impact and subsequent cognitive variability, thereby reducing understanding of social functioning in these children. Indeed, research from many domains, including children with learning disabilities (Bauminger, Edelsztein, &

Morash, 2005; Elksnin & Elksnin, 2004; Kavale & Forness, 1996; Tur-Kaspa & Bryan, 1994) and children with traumatic brain injury (Ganesalingam, Yeates, Sanson, & Anderson, 2007; Turkstra, McDonald, & DePompei, 2001; Yeates et al., 2004), suggests that cognitive and social deficits are closely tied. Moreover, several studies have found associations between survivors' non-verbal cognitive deficits and their social functioning (Bonner, et al., 2009; Carey, Barakat, Foley, Gyato, & Phillips, 2001). Finally, interventions designed to mitigate cognitive deficits have found unexpected improvements in social outcomes as well (Conklin, Reddick, et al., 2010; Mulhern, Khan, et al., 2004). Such findings highlight the significant relationship between cognitive and social functioning in survivors, further emphasizing the importance of assessing both domains when evaluating outcomes in survivors of pediatric cancer. However, it remains to be seen which cognitive areas are specifically involved in survivors' social deficits. That is, while the extant literature would suggest that executive functioning deficits, including difficulties with attention, working memory and processing speed would likely influence social functioning, these have not been specifically evaluated.

The limited research that has been done on social functioning in survivors of pediatric brain tumors suggests that these children face a unique set of psychosocial deficits that may be unlike those experienced by typically-developing children with social problems. Common social deficits include few friends and social isolation (Vannatta, Gartstein, Short, & Noll, 1998), lower perceptions of self-competence (Hardy, Willard, Watral, & Bonner, 2010), and poor long-term psychosocial outcomes (Maddrey et al., 2005; Schultz et al., 2007; Zebrack et al., 2004). Recent studies have begun to focus on the assessment of social skills and have demonstrated a specific deficit in facial expression recognition (Bonner, et al., 2008; Hubal et al., in press; Willard, Hardy, & Bonner, 2009). As facial expression recognition abilities have been shown to predict overall social behavior (Leppãnen & Hietanen, 2001; Marsh, Kozak, & Ambady, 2007),

this line of research has pointed towards a new direction of inquiry for improving our understanding of survivors' social deficits.

In contrast, studies of social functioning in survivors of ALL have often demonstrated relatively typical social functioning (Gerhardt, et al., 2007; Noll, et al., 1999; Noll et al., 1997), particularly when compared to survivors of brain tumors (Meeske, Katz, Palmer, Burwinkle, & Varni, 2004; Pogorzala et al., 2010). However, a recent study that explicitly examined dyadic friendships of survivors of ALL noted that survivors were not as engaged with their friends as compared to typically-developing children (L. F. Katz, Leary, Breiger, & Friedman, 2011). That is, survivors did not participate in the types of interactions, including imaginative play, that are known to require a sense of comfort, trust, and the ability to negotiate with a peer. Such results suggest that, in contrast to previous research (Noll, et al., 1999; Reiter-Purtill, Gerhardt, Vannatta, Passo, & Noll, 2003), survivors of ALL may have deficits in the more complex social skills needed to develop and maintain close friendships. As such, research with survivors of both brain tumors and ALL suggest that further assessment and understanding of social functioning is necessary for overall improvement in quality of life.

Despite this acceptance of decreased social competence as a significant late effect in survivors, few strides have been made in understanding the etiology of these deficits. Indeed, it is not known whether social incompetence is due to a lack of social skills, decreased exposure to peers, peer rejection, or some other factor. As such, it will be difficult to design interventions to improve social outcomes in survivors without a conceptual understanding of the nature and range of their deficits. For example, an intervention designed to promote understanding of empathy and social rules would be very different from one designed to ameliorate social anxiety.

The delay in understanding social functioning in survivors is compounded by the lack of appropriate measures validated within this group. The majority of measures

that have been used with survivors were designed to identify those children with problems indicative of psychopathology, e.g., conduct disorder, ADHD, anxiety disorders, etc. (*Conners' Rating Scales* (Conners, 1997, 2008), *Social Skills Rating System* (Gresham & Elliott, 1990, 2008), *Child Behavior Checklist* (Achenbach, 1991)). These measures tend to take a general and over-arching perspective on a broad array of externalized problem behaviors that may indicate clinically significant difficulties (e.g., bullying, teasing, impulsivity). However, research and clinical observations have demonstrated that survivors of CNS-impacting pediatric cancers are more likely to be quiet and unnoticed than loud and attention seeking (Vance, Eiser, & Horne, 2004; Vannatta, et al., 1998), and do not display the same types of problem behaviors as their peers (A. L. Thompson, Gerhardt, Miller, Vannatta, & Noll, 2009). Consequently, they do not show "elevations" on these measures (see Gartstein, Noll, & Vannatta, 2000) and look relatively average or normal (Patenaude & Kupst, 2005; Perrin, Stein, & Drotar, 1991). However, when interviewed, parents and other adults describe these children as unique and different, unable to find their place within the peer group (Vance, et al., 2004). Further, they are often described as unaware of social niceties, with little understanding of personal space and social tact. As such, survivors may be more likely to interrupt others who are speaking, misinterpret humor and sarcasm, or continue to speak, despite cues from others to stop. Unfortunately, there are few measures that explicitly assess these types of deficits (Barakat, et al., 2003).

This lack of understanding of survivors' social deficits and the lack of sensitive measures was particularly apparent in the evaluation of the three social skills interventions that have been completed (Barakat, et al., 2003; Barrera & Schulte, 2009; Die-Trill et al., 1996). While each of these projects had positive outcomes, each recognized that the evaluation of their effectiveness was limited by the measures used to assess changes in behavior. More specifically, each project hailed the necessity of gaining further understanding of the specific social deficits faced by survivors through a

more comprehensive assessment prior to the extension of these interventions (Barakat, et al., 2003; Barrera & Schulte, 2009). Barakat and colleagues (2003) in particular stated that, while parents rated the survivors included in their intervention within the normal range across most measures; in interviews, parents noted that difficulties with social functioning was one of their most prominent concerns about their children. Given these discrepant findings, the authors believed that the measures selected to assess social functioning in their study were not able to adequately capture the nature and extent of survivors' social difficulties. As such, they noted that assessment of specific social skills as well as social behavior would be a critical next step prior to the expansion of social functioning interventions for survivors (Barakat, et al., 2003).

Given that current research efforts have likely exhausted the information that can be obtained from these traditional measures of children's behavior, the theoretical basis for understanding social functioning in survivors must be expanded by first considering outcome variables in studies of typically developing children. The study of social functioning and peer relations in typically developing children has a rich history, one that has led to a number of models and measures that may provide a basis for understanding social functioning in survivors of pediatric cancer. Such models have broken down the process of social functioning into testable steps, providing a mechanism for understanding a child's particular experiences with peers.

## *1.3 Understanding Social Functioning Across Normative and Non-Normative Populations*

Examining social functioning in typically-developing children provides a means for understanding the differences or dysfunction that may be present in survivors. To this end, social functioning is likely best described as the integration of social *cognition*, social *competence* and social *adjustment*, each of which involves various skills, behaviors and/or interactions (Cavell, 1990). More broadly, social functioning involves the ability

to interact with peers, discern emotions, follow conversations, gain acceptance by a peer group, and establish and maintain long-lasting friendships (Asher, Parker, & Walker, 1996). In the long-term, social functioning affects academic adjustment and attainment, the ability to gain employment, the development of psychopathology, and the ability to establish and maintain social and romantic relationships (Bagwell, Newcomb, & Bukowski, 1998; Burt, Obradović, Long, & Masten, 2008; Deater-Deckard, 2001).

While a full understanding of survivors' difficulties with social functioning cannot be obtained without a thorough knowledge of typical functioning, it must be kept in mind that survivors' deficits may be influenced by factors related to having a significant medical condition. As such, it is also important to examine the social functioning of other groups of children who may have similar deficits and thus may provide a direction of inquiry that allows close comparison. One such group that has received extensive study is children who have suffered a traumatic brain injury (TBI) (Ganesalingam, et al., 2007; Hanten et al., 2008; Janusz, Kirkwood, Yeates, & Taylor, 2002; Spell & Frank, 2000; Yeates, et al., 2004). While a TBI is considered an acute injury, while the diagnosis and treatment of a brain tumor or ALL is a more chronic disease (Penkman, 2004; Poggi, et al., 2005), there are two similarities that set them apart from other groups of children who may experience social difficulties and thus make them a particularly appropriate comparison group. First, children who have suffered a TBI and survivors of pediatric cancer have both experienced a period of normal development prior to the illness or injury. The timing of the injury or diagnosis is particularly important, as it has been shown that children who are younger at the time of insult or diagnosis exhibit greater deficits in many areas (Anderson et al., 1997; Reimers et al., 2003), including social functioning. Second, survivors and children with TBI both experience cognitive deficits, typically within the executive functioning domain (Anderson, Godber, Smibert, Weiskop, & Ekert, 2004; Langer et al., 2002; Mathias et al.,

2004), that will likely impact their social abilities. Thus, assessment of cognitive functioning must be a part of any evaluation of social functioning.

Yeates and colleagues (2007) recently conceptualized a model of social functioning specifically for children with brain disorders, including TBI and brain tumors. Specifically, they suggested that traditional models of social functioning (like Crick and Dodge's (1994) often-used revised Social Information Processing Model (SIP-R)) may not be comprehensive enough to fully understand social functioning in children who have suffered some degree of brain damage. These children have a unique set of cognitive and social deficits that are a direct result of the brain insult, and the inclusion of the variants of the insult – including the type and location of the insult – are critical variables in understanding the deficits in this population. Furthermore, these insult variables will interact with developmental factors such as age and pre-morbid functioning (see Rey-Casserly & Meadows, 2008 for childhood cancer example). Therefore, based on decades of research into the social deficits of children with TBI, Yeates and colleagues (2007) proposed a heuristic model to understand social functioning in children with brain disorders that combined traditional social functioning models (the SIP-R) with insult-specific variables and a particular emphasis on the impact of cognitive functioning.

This model, termed the *Social Outcomes in Childhood Brain Disorder* (see Figure 1), encompasses knowledge from developmental psychology and cognitive neuroscience to explain the relationship among brain pathways, child development and social functioning outcomes (Yeates, et al., 2007). The model highlights relationships between several constructs, including: social functioning, peer relationships, problem solving, communication skills, and cognitive functioning, together with the neuroanatomical sequelae that underlie the development and dysfunction of each (Yeates, et al., 2007).

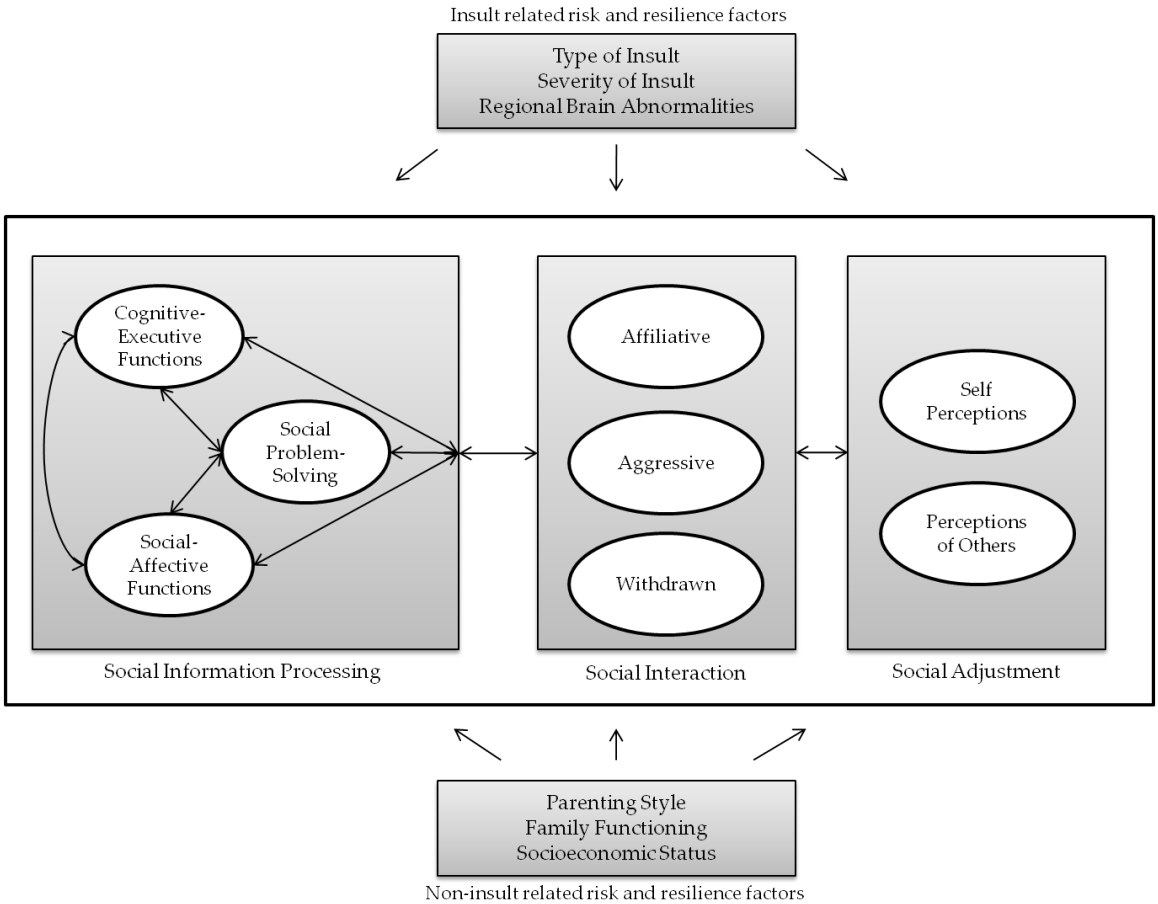


**Figure 1: Social Outcomes in Childhood Brain Disorder (adapted from Yeates, et al., 2007)**

However, while the heuristic suggests a direction of inquiry, it does not dictate specific measures or methodologies to determine specific areas of deficit. As such, for the purpose of empirical evaluation, the model had to be adapted in this paper to include constructs specific to social functioning in survivors of CNS-impacting pediatric cancer based on prior research.

## *1.4 Proposed Model of Social Functioning in Survivors of Pediatric Cancer*

The over-arching objective of the current paper is to evaluate components of the theoretically-derived model of social functioning adapted from Yeates and colleagues (2007) in survivors of pediatric brain tumors and ALL (see Figure 2), using research

from several areas including pediatric psychology, social development, and social cognitive neuroscience. While the evaluation of the entire model is beyond the scope of the current paper, the initial assessment of the three main factors – neurocognitive skills, social-cognitive skills and social experience – and the relationships among them have provided compelling early-stage data to guide understanding of the deficits in social functioning faced by survivors of pediatric brain tumors and ALL. These three factors are described in detail below.

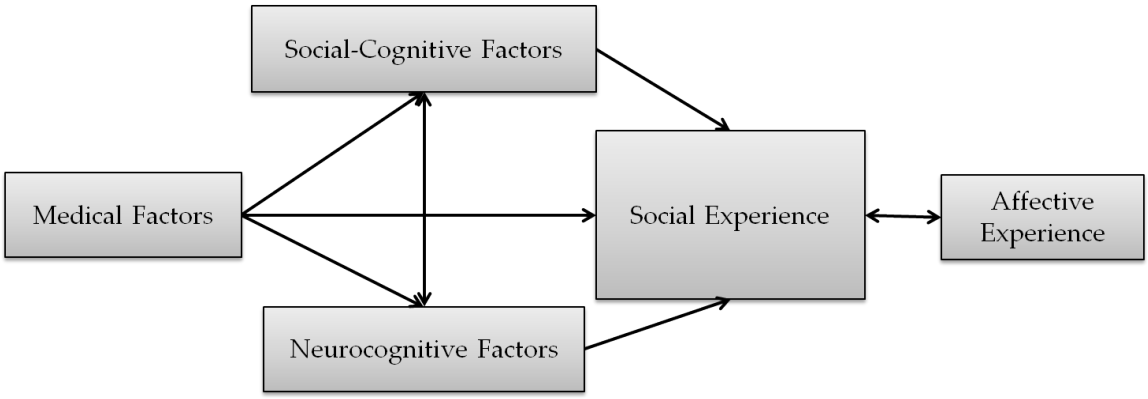


**Figure 2: Proposed model of social functioning in survivors of pediatric cancer**

### 1.4.1 Neurocognitive factors

As discussed above, neurocognitive deficits are perhaps the most prevalent late effect faced by survivors of pediatric brain tumors, with estimates suggesting that they are present in 40 to 100% of survivors (Mulhern & Palmer, 2003). While deficits faced by survivors of ALL are less severe, they are still common, present in at least 30% of survivors (Campbell, et al., 2007). Several decades of research have demonstrated that declines in attention, processing speed and working memory underlie the changes in intelligence and academic performance frequently seen in survivors (Butler, 1998; Dennis, Hetherington, & Spiegler, 1998; Palmer, et al., 2007; Reddick, et al., 2003; Schatz, Kramer, Ablin, & Matthay, 2000). In healthy children, Fry and Hale (1996) determined

that almost half of developmental increases in IQ could be attributed to age-related improvements in working memory and processing speed. Similar findings have been documented in pediatric cancer survivors. Schatz and colleagues (2000), for example, found that 45% of the variance in IQ was attributable to these processes. Moreover, Reddick and colleagues (2003) demonstrated that 70% of survivors' functional impairments at school and in other settings were accounted for by their attention problems. From a neuroscience perspective, attention, working memory and processing speed are mitigated by white matter in the brain (Nagy, Westerberg, & Klingberg, 2004); white matter is also the brain tissue that is most susceptible to damage from radiation and chemotherapy (Fouladi et al., 2004; Reddick, Glass, Johnson, Laningham, & Pui, 2009).

Given this research, it is reasonable to expect that deficits in attention, working memory, and processing speed likely contribute to survivors' social problems as well. However, no previous research has directly examined the impact of these specific processes on social functioning. Studies have, however, evaluated the impact of deficits in IQ, particularly when survivors were compared to other groups of children; not surprisingly, these studies found associations between intellectual skills and aspects of social functioning (see Bonner, et al., 2008 for an example). As such, the current study has assessed three specific areas of cognitive functioning: attention, working memory and processing speed. These areas were evaluated in cancer survivors alongside a control group: children with ADHD. Importantly, children with ADHD have documented deficits in attention and working memory (Barkley, 1997) as well as in social functioning (Hoza, 2007), but tend to have IQ scores within normal limits.

### 1.4.2 Social-cognitive factors

Social-cognitive factors are defined as the foundational aspects of social skills that influence the social experience and adjustment of a child (Cavell, 1990; Yeates, et al., 2007), and include skills such as facial expression recognition (a nonverbal skill), and social problem-solving (an information processing skill). Facial expressions are a rich source of social information (Blair, 2003), and the accurate interpretation of them is associated with better social functioning (Leppãnen & Hietanen, 2001; Mostow, Izard, Fine, & Trentacosta, 2002; Nowicki & Carton, 1997; Nowicki & Duke, 1992). Further, recent research has demonstrated that survivors of pediatric cancer struggle with facial expression recognition (Bonner, et al., 2008; Hubal, et al., in press; Willard, et al., 2009). Indeed, survivors were able to correctly identify significantly fewer of the emotions portrayed in adult and child facial expressions as compared to children with arthritis, despite controlling for significant group differences in intelligence (Bonner, et al., 2008). Of note, several other studies have also revealed deficits in facial expression recognition in children with ADHD (Cadesky, Mota, & Schachar, 2000; Pelc, Korneich, Foisy, & Dan, 2006).

Given this substantial evidence, social-cognitive skills such as facial expression recognition appear critical for understanding the factors that influence a child's social behavior. They are also skills that could potentially be taught so as to influence a child's social experience (described next), whereas children's social reputations and their perceptions of others, are often difficult to change. As such, this identification of behavior and skills represents a more practical piece of social functioning as described by the model.

### 1.4.3 Social experience

Social experience is the day-to-day peer interactions of a child or adolescent. This component of the model differs from the other factors as it is attempting to quantify the interpersonal interactions of children through the perception and ratings of outside observers, rather than through demonstration by the child. For the current study, the outside observers were parents, and the measures captured information such as a child's interpretation of nonverbal social behavior (Duke & Nowicki, 2005) and the extent to which a child experiences negative social interactions such as teasing, isolation, and immature interests (e.g., as suggested by preferences for playing with younger children) (Achenbach, 1991; Conners, 2008).

## *1.5 Current Study*

Overall, this conceptualization of social functioning in survivors of pediatric cancer expected that cognitive and social-cognitive skills provide the foundational building blocks that influence a child's social experience. This is parallel to the process in cognitive functioning where attention, working memory and processing speed provide the means necessary for the development and maintenance of intelligence and academic achievement. Of note, while there is limited empirical research to substantiate this hypothesis, there are assumptions based in theory to support this hypothesis (e.g., Crick & Dodge, 1994; Yeates, et al., 2007). In the context of the current study and as presented in Figure 2, this model allows for the demarcation of social functioning into several parts, thus providing a more comprehensive method of assessment.

With this conceptual understanding of social functioning in children, and most specifically in survivors of pediatric cancer, the current study reflects the initial evaluation of this new model of social functioning. While assessment of the entire model is beyond the scope of this paper, the model provides a preliminary guide to

further understand social functioning in survivors of CNS-impacting pediatric cancer. Additionally, two control groups are included – typically-developing children and children with ADHD – in an effort to understand typical social functioning, as well as the influence of attention problems.

The first hypothesis to be tested using this model is that survivors of pediatric brain tumors and ALL will have poorer functioning than either typically developing children or children with ADHD. These deficits should be apparent across all domains of the model, including neurocognitive skills, social-cognitive skills, and social experiences. The second hypothesis is that performance in neurocognitive skills and social-cognitive skills will be associated with the social experience in all participants.

# 2. Methods

## *2.1 Overview*

The study objectives were assessed using a sample of 70 children aged 8 to 16: 19 survivors of CNS-impacting pediatric cancer, 10 children with ADHD, and 41 typically-developing children. Survivors were recruited from the Department of Pediatric Hematology/ Oncology at Duke Children's Hospital. Children with ADHD and typically-developing children were recruited from the community. All data were collected through a one-time clinic visit, for which children and their parents received compensation in the form of small-value gift cards. Medical data of survivors were verified by chart review.

## *2.2 Procedures*

Survivors of CNS-impacting cancer were approached by a research assistant during a regularly scheduled neuropsychology appointment. Within the Department of Pediatric Hematology/Oncology, the vast majority of children diagnosed with either a brain tumor or ALL are referred for routine neuropsychological evaluations during the survivorship period.

Typically-developing children were recruited through an advertisement placed on a clinical trials website maintained by Duke University Medical Center (dukehealth.org). Interested families were invited to call a research assistant to learn more information and to set up an appointment for participation. Brief screening procedures were completed during this phone call to ensure that children did not have a chronic medical illness.

Children with ADHD were eligible for participation and were recruited via two means. First, an advertisement was placed on the clinical trials website used to recruit typically-developing children (dukehealth.org). Second, advertisements were also placed in several local psychology offices that typically treat children with ADHD. All diagnostic subtypes of ADHD (predominantly inattentive, predominantly hyperactive-impulsive, and combined) were eligible for participation.

During the two-hour study visit, a research assistant first met with both the child and parent to complete consent using Institutional Review Board (IRB) approved procedures. Then, parents completed a variety of questionnaire measures while children worked with a research assistant to complete study measures. Following completion of all measures, children and their parents were provided with a gift card to a local superstore.

## *2.3 Participants*

A final sample of 19 survivors of CNS-impacting cancer participated in the current study. Survivors were an average age of 12.2 years (SD = 1.69, range 9.7 to 15.2 years). The majority of survivors were male (57.9%) and Caucasian (84.2%). With regard to treatment history, 9 (47.4%) children were survivors of ALL, while the diagnoses of brain tumors were varied and included medulloblastoma, ependymoma, optic glioma, astrocytoma, pineoblastoma and primitive neuroectodermal tumor (PNET). Survivors were treated with a combination of chemotherapy (84.3%), cranial radiation (52.7%), and surgery (47.4%). One child received a bone marrow transplant. Two children received ventriculoperitoneal (VP) shunts to control hydrocephalus. On average, survivors were diagnosed at 4.9 years of age (SD = 2.51, range 1.9 to 9.6 years of age), and were 5.5 years post-treatment (SD = 2.38, range 1.8 to 10.9 years) at the time of

the study visit. For more demographic and treatment information on this sample see Table 1.

A final sample of 41 typically-developing children (48.8% male) participated in the study. Typically-developing children were 53.7% Caucasian and an average age of 12.0 years (SD = 2.31, range 8.0 to 16.3 years) at the time of study. For more demographic information on this sample see Table 2.

The final sample of children with ADHD included 10 children aged 9.3 to 14.7 years (mean age = 12.3; SD = 1.95). The sample was 70% male and varied considerably by race. See Table 2 for all demographic information. Of note, according to parent reports, 70% of the sample (n = 7) was on at least one ADHD medication at the time of study.

There were no statistically significant differences between groups on any demographic variables.

## *2.4 Measures*

### 2.4.1 Child-completed measures

*Diagnostic Analysis of Nonverbal Accuracy – Revised* (DANVA2; Nowicki, 2006; Nowicki & Duke, 1994). The DANVA2 is a 48-item measure of facial expression recognition. This measure contains two subtests – Adult Faces and Child Faces. Participants are presented with a photograph and asked to assess the facial expression portrayed from four choices: happy, sad, angry and fearful. Performance is assessed by number of errors committed, with z-scores calculated to account for age of participant, as performance is known to improve with age. The Child Faces subtest of the DANVA2 was used as a measure of Social-Cognitive Skills for the current study.

*Facial Expression Recognition Instrument* (FERI; Hubal, et al., in press; Hubal et al., 2008). The FERI is a new measure of digital facial expression created using responsive virtual human technology (RVHT), an innovative technology that uses computer modeling to create lifelike human figures. The FERI consists of 48 faces portraying six different emotions: happy, sad, angry, fearful, surprise and disgust. Facial expressions were created using the Facial Action Coding System (Ekman & Friesen, 1978), which divides the face into 46 different muscle groups. Each emotion reflects a specific combination of muscles. For the current study, participants were asked to assign the facial expression portrayed by each face to one of the six choices. The FERI was used to assess Social-Cognitive Skills.

*Woodcock Johnson Tests of Cognitive Abilities – 3rd edition* (WJ-III Cog; Woodcock, McGrew, & Mather, 2007). The WJ-III Cog is a widely-used measure of cognitive abilities, comparable to the well-known Wechsler Scales (Wechsler, 2003). It measures several areas of cognition including verbal intelligence, perceptual reasoning, working memory and executive functioning. The Processing Speed Index and the Working Memory Index, each of which consists of two subtests, were used to assess Neurocognitive Skills.

### 2.4.2 Parent-completed measures

*Child Behavior Checklist* (CBCL; Achenbach, 1991). The CBCL is a well-known parent-report questionnaire that assesses psychosocial functioning of children aged 6 to 18. Domains assessed include internalizing and externalizing problems, attention problems, mood concerns, and conduct concerns. The Social Problems subscale was used to measure Social Experience.

*Emory Dyssemia Index* (EDI; Duke & Nowicki, 2005). The EDI is a 42-item parent-completed measure that assesses nonverbal aspects of social functioning. Example subscales include: Gaze and Eye Contact, Space and Touch, and Nonverbal Receptivity. For the EDI, higher scores represent worse nonverbal functioning, with scores above 71 suggesting clinical levels of difficulty with nonverbal social behavior. A Total Score was used to assess Social Experience.

*Conners' Parent Rating Scale – 3rd edition* (Conners 3; Conners, 2008). The Conners 3 is a 41-item parent-completed questionnaire that assesses several areas of cognitive and behavioral functioning, including hyperactivity/impulsivity, executive functioning, learning problems, aggression, peer relations, and inattention. Two subscales were used: the Peer Relations scale was used to assess Social Experience, and the Inattention subscale was used to measure Neurocognitive Skills.

## *2.5 Analytical Plan*

The hypotheses being tested in this study were assessed using a combination of independent sample t-tests, bivariate correlation matrices and regression models. First, the performance of survivors was compared separately to children with ADHD and typically-developing children across the three primary areas of interest: neurocognitive skills, social-cognitive skills, and social experience using independent sample *t*-tests. Given that multiple analyses will be conducted to determine differences between groups, the Hochberg modified Bonferroni procedure (Hochberg, 1988) was used to guard against inflated Type I error rate. This procedure requires the ordering of *p*-values from highest to lowest, with the most significant value compared to a criterion alpha value of .05/1 (.05) and the second to an alpha of .05/2 (.025).

For the next set of analyses, data from all participants were combined. Two correlation matrices were then computed to assess the associations between social experience and the two skill-based domains: neurocognitive skills and social-cognitive skills. Finally, those measures with the strongest associations were inputted into regression models to determine the predictive value of neurocognitive and social-cognitive skills for social experience.

# 3. Results

## *3.1 Group Differences in Functioning*

To determine group differences in functioning across the three domains, several independent sample *t*-tests were performed. Given the large number of analyses, a Hochberg modified Bonferroni procedure (Hochberg, 1988) was employed for each domain to protect against Type I error rate. Tables 3 and 4 outline the criterion *p*-values used to determine significance.

### 3.1.1 Neurocognitive skills

To determine difference in neurocognitive skills between survivors of pediatric cancer and typically-developing children, three independent sample *t*-tests were performed (see Table 3). Results revealed that survivors evidenced slower processing speed ($t = -2.90$, $p < .025$) and more parent-rated attention problems ($t = 2.72$, $p < .05$) than typically-developing children. In contrast, there was no difference between groups on a test of working memory ($t = -1.65$, NS). An additional set of analyses was completed to determine differences between survivors of pediatric brain tumors and typically-developing children (see Table 4). Three independent sample *t*-tests revealed that survivors demonstrated slower processing speed ($t = -3.33$, $p < .05$) and more difficulties with parent-rated inattention ($t = 3.24$, $p < .025$) than typically-developing children.

A third set of three independent sample *t*-tests was performed to assess differences in neurocognitive skills between survivors and children with ADHD (see Table 5). Analyses revealed that children with ADHD experienced greater parent-rated attention problems ($t = -3.18$, $p < .05$). There were no differences between groups on

measures of processing speed or working memory. However, examination of the means revealed a two-thirds of a standard deviation difference between survivors and children with ADHD in processing speed, with survivors evidencing slower speeds, suggesting a clinically meaningful difference in functioning.

### 3.1.2 Social-cognitive skills

Independent sample *t*-tests completed to determine differences between survivors and typically-developing children on measures of facial expression recognition revealed that survivors performed more poorly than typically-developing children on the Child Faces DANVA2 ($t = -2.73$, $p < .05$). There were no differences between groups on the FERI (see Table 3). In contrast, when just survivors of pediatric brain tumor were compared to typically-developing children, there were significant differences between groups on both the FERI ($t = -2.34$, $p < .025$) and the Child Faces DANVA2 ($t = -3.99$, $p < .05$; see Table 4). Comparisons between all survivors of pediatric cancer and children with ADHD revealed no differences between groups across the two measures of facial expression recognition: Child Faces DANVA2 ($t = 0.56$, NS), and the FERI ($t = 0.87$, NS). See Table 5 for measure means and standard deviations for each group.

### 3.1.3 Social experience

As hypothesized, there were differences between survivors of pediatric cancer and typically-developing children on measures of parent-rated social experience (see Table 3). Survivors evidenced more social problems ($t = 3.22$, $p < .05$) and more difficulties with nonverbal social behavior ($t = 3.20$, $p < .025$) than typically-developing children (see Table 3). Additionally, survivors of pediatric brain tumors demonstrated

more difficulties on the CBCL Social Problems ($t = 3.62$, $p < .05$) and on the EDI ($t = 2.88$, $p < .025$) than typically-developing children (see Table 4). In contrast, there were no differences in peer relations ($t = 0.75$, NS). Analyses revealed that parents rated children with ADHD as having more social problems (as measured by the CBCL) than survivors of pediatric cancer ($t = -2.14$, $p < .05$). On the other hand, there were no differences between groups on the other two measures of social experience: Conners' Peer Relations ($t = -0.82$, NS) and the EDI ($t = -1.48$, NS). See Table 5 for all measure means and standard deviations.

## *3.2 Associations between Social Experience and Skill-Based Domains*

To determine associations between social experience and neurocognitive skills, a correlation matrix was computed. Results revealed several significant associations between attention problems, working memory, processing speed and measures of social experience (see Table 6). Specifically, poorer working memory, slower processing speed, and more attention problems were all significantly associated with difficulties in social functioning. A second correlation matrix was computed to determine associations between social-cognitive skills and social experience. Analyses revealed significant associations between Child Faces DANVA2 and the FERI and measures of social experience, such that poorer facial expression recognition was significantly associated with more social experience difficulties. See Table 6 for all correlations.

Given the particular interest in the functioning of survivors of pediatric cancer, two exploratory correlation matrices were computed to determine associations between social experience and neurocognitive skills and social experience and social-cognitive skills (see Table 7). In the neurocognitive domain, results revealed significant associations between processing speed and peer relations ($r = -.62$, $p < .05$), as well as

parent-rated inattention and social problems ($r = .64$, $p < .05$) and the EDI ($r = .79$, $p < .001$). Within the social-cognitive domain, results revealed significant associations between the Conners' Peer Relations scale and the Child Faces DANVA2 ($r = -.66$, $p < .03$) and the CBCL Social Problems scale and the FERI ($r = -.64$, $p < .01$). No other analyses reached significance, however this was likely due to the small sample size as the *r*-values were moderate for many other associations (see Table 7).

## *3.3 Predictors of Social Experience*

To determine neurocognitive and social-cognitive predictors of social experience, a series of three regression analyses were performed with the three measures of social experience serving as outcome measures: Social Problems, Peer Relations, and EDI. Predictors included those measures of neurocognitive and social-cognitive skills that were significantly associated with social experience: inattention, working memory, processing speed, Child Faces DANVA2 and the FERI (see Table 8).

All three regression models were significant, accounting for 61 to 72% of the variance. The model predicting the Social Problems subscale from the CBCL accounted for .61 of the variance. Additionally, two individual predictors reached significance – inattention ($\beta = 0.44$, $p < .05$) and Child Faces DANVA2 ($\beta = -0.39$, $p < .05$) – suggesting that children with more attention problems and those who have more difficulty interpreting facial expressions experience more social problems. Of note, there was also a trend for the FERI ($\beta = -0.25$, $p = .08$), suggesting that children who have difficulty identifying adult facial expressions may also experience greater parent-reported social problems.

The regression model predicting the Peer Relations subscale of the Conners' 3 was significant, accounting for .60 of the variance. Again, two individual predictors

reached significance: inattention ($\beta = 0.34$, $p < .05$) and Child Faces DANVA2 ($\beta = -0.42$, $p < .05$). Specifically, children with more attention problems and those who had more difficulty correctly identifying child facial expressions were more likely to experience difficulties with peer relations.

The regression model predicting the EDI was also significant, accounting for .72 of the variance. Two individual predictors reached significance: inattention ($\beta = 0.78$, $p < .001$) and Child Faces DANVA2 ($\beta = -0.22$, $p < .05$), suggesting that children with greater attention problems and those who had more difficulty identifying child facial expressions had more difficulty with nonverbal social behavior.

# 4. Discussion

The purpose of the current study was to further our understanding of social functioning in survivors of CNS-impacting pediatric cancer through the completion of two aims. The first aim was to determine differences in social functioning between survivors of CNS-impacting cancer and two control groups: typically-developing children and children with ADHD. By adding the second control group, children with ADHD, the current study sought to deepen understanding of the impact of attention problems on social functioning. The second aim was to assess the association between neurocognitive skills, social-cognitive skills and social experience so as to provide preliminary support for our model of social functioning (see Figure 2).

Analyses revealed, as hypothesized, significant differences in functioning between survivors and typically-developing children across each of the three domains of interest. Indeed, survivors of brain tumors and ALL demonstrated significantly more parent-rated attention problems, slower processing speed, more difficulties with facial expression recognition and a more difficult parent-rated social experience than typically-developing children. Such findings are particularly important to highlight given that past research has frequently demonstrated that survivors generally display no deficits in social functioning (see Boman & Bodegård, 2004; Gerhardt, et al., 2007; Noll, et al., 1999; Reiter-Purtill, et al., 2003 for examples). Unsurprisingly and consistent with past research (Bonner, et al., 2008; Hardy, et al., 2010; Vannatta, et al., 1998), when survivors of brain tumors were compared to typically-developing children, they demonstrated significant difficulties in functioning across the majority of measures, including inattention, processing speed, facial expression recognition, and parent-reported social problems.

The hypotheses were only partially supported when survivors were compared to children with ADHD across the domains of interest. As expected given the nature of the

ADHD diagnosis (American Psychiatric Association, 2000), children with ADHD had more attention problems than survivors of pediatric cancer. Contrary to the starting hypothesis, however, there were no differences between survivors and children with ADHD across the other domains, including facial expression recognition and two of the three measures of social experience. However, on the final measure of social experience, parents of children with ADHD indicated more social problems than parents of survivors of pediatric cancer. Further, when means across all measures were compared, children with ADHD exhibited more difficulties with both facial expression recognition and nonverbal social behavior, although these analyses did not reach significance. This result, while somewhat unexpected, is not fully surprising given the extensive literature describing difficulties with social functioning in children with ADHD (Hoza, 2007; Nijmeijer et al., 2008).

It should be noted that parents of the children with ADHD who participated in this study rated their children as significantly hyperactive and impulsive, both as compared to survivors of cancer and as compared to normative data (data available upon request). As such, it is possible that the sample of children with ADHD enrolled in this study were either diagnosed with the Predominantly Hyperactive or Combined Type of ADHD (American Psychiatric Association, 2000). Survivors of pediatric cancer, while often having difficulty sustaining attention and mental effort, are infrequently hyperactive and impulsive (Kahalley et al., 2011; Krull et al., in press). Instead, they tend to display a profile more consistent with sluggish cognitive tempo (Reeves et al., 2007). In the ADHD literature, children with sluggish cognitive tempo are often described as lethargic, prone to day dreaming and staring, and unorganized (Harrington & Waldman, 2010; Hartman, Willcutt, Rhee, & Pennington, 2004; McBurnett, Pfiffner, & Frick, 2001); as such, they display a behavioral profile in stark contrast of those children who are more hyperactive and/or impulsive. Given this understanding of survivors' cognitive profile, this significant difference in externalizing behaviors between the

groups may have artificially increased the differences in social functioning as well. Future studies that use children with ADHD as a comparison group may select to limit enrollment to children with Predominantly Inattentive Type to reduce this bias. However, as this is the first known study to compare these two groups of children, further study of the social functioning experienced by survivors as compared to children with ADHD is certainly warranted.

With regards to the second aim, regression analyses revealed that parent-rated attention problems and facial expression recognition as measured by the DANVA2 were significantly predictive of parent perceptions of a child's social experience. More specifically, children who had trouble paying attention and who had more difficulty correctly labeling facial expressions also experienced more difficult social lives. Of interest, no other predictor – including processing speed, working memory and facial expression measured by the FERI – reached significance. Overall, these analyses provide limited preliminary support for the new model of social functioning and indicate that the measurement of neurocognitive and social-cognitive skills may be a strong indicator of overall social functioning.

Attention problems were the strongest neurocognitive predictor of social experience. Difficulties with attention are also one of the most common cognitive late effects experienced by survivors of CNS-impacting cancer (see Anderson, et al., 2004; Mabbott, Snyder, Penkman, & Witol, 2009; Patel, Lai-Yates, Anderson, & Katz, 2007 for examples). Indeed, recent research has suggested that the treatments used to target childhood cancer directly impact the biological pathways responsible for attention abilities (Kamdar, et al., 2011; Krull, et al., 2008). Moreover, while research has documented that survivors of CNS-impacting cancer do not actually develop ADHD post-treatment (Kahalley, et al., 2011; Krull, et al., in press), they certainly do experience significant attention problems that affect both their cognitive and social functioning (Mulhern, Merchant, Gajjar, Reddick, & Kun, 2004; Patel, et al., 2007). Further, attention

problems are the hallmark of the ADHD diagnosis (American Psychiatric Association, 2000) and have been linked to their difficulties with social functioning (Semrud-Clikeman, 2010; Shin, Lee, Kim, Park, & Lim, 2008). As such, the results of the current study, combined with past literature, are strongly indicative of the role of attention in social functioning.

Somewhat surprisingly, working memory and processing speed were not predictive of social experience, although they were associated with measures of social experience. Given the interconnectedness of the three neurocognitive skills measured in this paper (*r* values range from .31 to .44) (e.g., Fry & Hale, 1996), it is reasonable to hypothesize that working memory and processing speed would also influence social experience, given that attention did. Further, there is some evidence from research completed with children diagnosed with autism (Williams, Goldstein, & Minshew, 2005) and social anxiety (Amir & Bomyea, 2011) that working memory is associated with social functioning outcomes. In contrast, there is no research to support a link between processing speed and social functioning, although such a link is theoretically plausible, as a child's ability to quickly analyze presented information will likely significantly impact his/her capacity for adequate social functioning. Further exploration of the influence of these two neurocognitive skills on social functioning is certainly warranted, particularly in children with ADHD, a group with known deficits in working memory (Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005) and survivors of pediatric cancer, who have known deficits in working memory and processing speed (Aukema et al., 2009; Mennes et al., 2004; Reimers, Mortensen, & Schmiegelow, 2007).

With regards to the social-cognitive domain, facial expression recognition was a strong individual predictor as measured by the Child Faces DANVA2. Past research has indicated that both survivors of pediatric cancer (Bonner, et al., 2008; Hubal, et al., in press) and children with ADHD (Cadesky, et al., 2000; Pelc, et al., 2006) experience significant deficits in facial expression recognition. Further, facial expression

recognition is associated with social adjustment in typically-developing children (Leppãnen & Hietanen, 2001), with the accurate identification of fear in particular predicting positive social behavior (Marsh, et al., 2007). Future research in facial expression recognition may wish to focus on the development of this deficit in survivors. Indeed, it is currently unclear as to why survivors demonstrate such a strong impairment in facial expression recognition. While it may be that survivors' development of this skill over time is stunted by the limited social interaction with peers that is inherent due to the treatment required to cure their disease; it is perhaps more likely that deficits in facial expression recognition are a function of accompanying declines in executive functioning or perceptual reasoning. Certainly the results of the current study would support a strong interplay between facial expression recognition and inattention in particular, and suggests that facial expression recognition is a skill that should both be further explored and targeted in social functioning interventions designed for survivors of pediatric cancer.

## *4.1 Limitations*

While the current study provides a solid direction of inquiry for future research, the results must be interpreted in light of a number of limitations. Perhaps the most notable limitation is the small sample sizes of the three comparison groups. Specifically, with only nineteen survivors of childhood cancer (ten survivors of brain tumors and nine of ALL) we were unable to complete diagnosis- or treatment-specific analyses, thus preventing our analyses of an entire domain of our model of social functioning (Figure 2). Indeed, it is likely that certain treatment factors such as history of radiation therapy and time-off treatment, as well as the diagnostic factor of either ALL or brain tumor, would significantly impact survivors' performance on measures and thus influence overall social functioning. It is notable that these are known risk factors for deficits in

cognitive and social functioning post-cancer treatment (Bonner, et al., 2008; Reimers, et al., 2003; Willard, et al., 2009). Further, the inclusion of survivors of ALL likely raised the mean overall performance of survivors across domains. Indeed, it is well known that children with ALL are treated with less neurotoxic substances than children with brain tumors, and as such, they are less susceptible to severe late effects (Meeske, et al., 2004). Exploratory analyses completed comparing survivors of brain tumors to survivors of ALL revealed significant differences across several measures, including processing speed, the FERI, and CBCL Social Problems (data available upon request). As such, the current study is limited in the conclusions that can be made regarding the social functioning of survivors of pediatric brain tumors in particular, and future studies should make recruiting a larger sample of survivors of brain tumors a priority.

A second limitation is the small overall sample size: 70 total participants and only ten with ADHD. The limited sample size impacted the ability to complete between-group analyses, thus forcing the combination of all groups when completing both correlation and regression analyses. Further, missing data across subjects meant that many analyses were completed with far fewer children, further limiting the conclusions that can be drawn from analyses. Indeed, it may be that while inattention and facial expression recognition truly are strong predictors of social experience, other factors may also be involved, but to a lesser degree that could not be captured by a small sample size. Therefore, while the results of the current study do provide important preliminary information regarding our understanding of overall social functioning, the study cannot draw conclusions regarding the potential differences among the three groups. More specifically, while it is certainly reasonable to assume that neurocognitive and social-cognitive skills will impact the social experience of all children, this hypothesis could not be confirmed in the current study due to limited sample size. Future studies will need to expand the sample size across all three groups of children so as to permit more sophisticated between- and within-group analyses.

Another limitation lies in the selection of measures. The lack of non-parent report measures of social experience significantly reduced the ability to fully understand children's social experiences. Indeed, parents are often biased reporters of their children's functioning, particularly in the social realm, as they infrequently have a comparison (e.g., other children) against which to base their ratings (Schneider & Byrne, 1989). Future studies should make it a priority to collect teacher ratings of social experience, as teachers observe the functioning of children in comparison to their classmates and thus will likely present a less-biased view than parents (Renk & Phares, 2004). Indeed, it has been suggested that the ideal assessment of social functioning would include both teacher and parent evaluations so as to provide a comprehensive view of children's social experiences (Merrell, 2001). Finally, perhaps more so than in any other domain, it also will be important to assess self-perception of social experience as children's views of their experiences will provide a unique viewpoint that will deepen our understanding of children's social lives. Whether this is done through self-report measures or through observations of children's peer interactions, children's report of their own social experiences will be a critical step to furthering our understanding of this construct.

## *4.2 Future Directions*

### 4.2.1 Continued assessment of social functioning

The current study attempted to further understanding of social functioning in survivors of pediatric cancer by determining those factors that might play a role in functioning. Specifically, similar to the research that has determined that deficits in certain neurocognitive skills yield overall declines in intelligence and academic functioning (Schatz, et al., 2000), the current study sought to elucidate the skill-based factors that may lead to deficits in social functioning.

While the study provided support for the influence of neurocognitive and social-cognitive skills on social experiences, further research is required to fully demarcate the relationship between skill-based and experiential domains. Such an undertaking will require creativity in assessment as the measurement of social functioning has lagged far behind the evaluation of cognitive functioning. Indeed, while the current study focused on one social-cognitive skill: facial expression recognition; there are likely several other skills that were not assessed that may play a greater role in social outcomes, including social problem-solving (Asher, MacEvoy, & McDonald, 2008).

Research has suggested that the assessment of children's strategies in social situations is essential for identifying concrete intervention targets (Asher, et al., 2008; D'Zurilla & Goldfried, 1971). The second piece of social problem-solving, assessment of children's social goals, attempts to explain the factors that may drive their behavior in a given situation and may explain a child's selection of one strategy over another (Asher, et al., 2008; Erdley & Asher, 1999; Ojanen, Gronroos, & Salmivalli, 2005; Renshaw & Asher, 1983). As such, a child's failure to competently behave in a situation may have more to do with his/her selection of an inappropriate goal than his/her lack of knowledge about how to act in that situation (Asher, et al., 2008). Therefore, assessment of children's strategies and goals will be an essential component to understanding overall social functioning.

Unfortunately, beyond facial expression recognition and social problem solving, there appear to be few other identified social-cognitive skills that may influence social functioning. Indeed, a recent article (Crowe, Beauchamp, Catroppa, & Anderson, 2011) reviewed over eighty measures of social functioning and determined the vast majority of measures tended to assess broad social competence, while many fewer were skill-based. Those skill-based measures tended to focus on emotion regulation, interpretation of body language, and understanding of irony. However, they noted that the assessment of social competence tends to rely on identifying children who have difficulties with

social competence, without evaluating *why* children may have these difficulties. As such, many assessments are limited in the information they can provide regarding potential targets for intervention (Crowe, et al., 2011). Given this state of the social functioning assessment literature, it may be that future studies will have to be particularly resourceful in the selection, and perhaps even in the design, of measures of social-cognitive skills.

As mentioned above, future assessment of social experience will also require further creativity. First, the measures of social experience used in the current study were completed by parents, and two of the three – the Social Problems scale from the CBCL and the Peer Relations scale from the Conners' 3 – were actually subscales of larger measures of adaptive and clinical behavior and not specific measures of social functioning. Indeed, only the EDI was a full measure of social functioning. In their review, Crowe and colleagues (2011) cautioned against the use of social functioning subscales from larger measures of adaptive behavior as they may lead to an over-interpretation of abilities from a small number of items. Further, two measures of social experience – the CBCL and the Conners' 3 – focused almost completely on the assessment of problems in social functioning, e.g., teasing, loneliness, and isolation. In contrast, the EDI focused on the evaluation of a child's ability to use nonverbal social behaviors such as maintaining appropriate personal space, using eye contact, and understanding of social norms. The use of these measures limited the type of information gathered regarding peer interactions, social initiative and other peer-based social behaviors. Therefore, it will be important to continue the evaluation of social functioning by selecting measures of social experience that both fully evaluate the construct and use multiple raters.

### 4.2.2 Potential for targeted interventions

A second area of future research will likely focus on the design and implementation of targeted interventions. Currently there are insufficient data to design an effective, evidence-based social functioning intervention for survivors of childhood cancer. However, it is reasonable to begin a discussion of the *types* of interventions that would be feasible to evaluate. Given the results of the current study, as well as prior research, two categories of interventions are indicated. The first would focus primarily on the improvement of neurocognitive skills and on attention in particular. Several such interventions have already been evaluated in survivors of childhood cancer (Askins & Moore, 2008; Butler, Sahler, et al., 2008). For example, Mulhern and colleagues (2004) evaluated the efficacy of a stimulant medication, methylphenidate, to improve attention problems in survivors of ALL and brain tumors. Results not only revealed improvements in parent- and teacher-reported attention problems, but also noted improvements in teacher-reported social functioning (Conklin, Reddick, et al., 2010). While an unexpected finding at the time, the results of the current study certainly support the relationship between attention problems and social functioning.

Other recently evaluated interventions for cognitive deficits have focused on non-medication approaches such as cognitive remediation (Butler, Copeland, et al., 2008; Kesler, et al., 2011; Patel, et al., 2009) and computerized cognitive training (Hardy, et al., 2011). While neither of these approaches has specifically measured their impact on social functioning, it stands to reason that they may also have a positive effect.

The second category of possible social functioning interventions for survivors includes a focus on social-cognitive skills such as facial expression recognition. Unfortunately, few interventions of this kind exist. The most common social skills interventions were designed for use with children and adolescents with Asperger's Disorder or high-functioning autism (Carter, Sisco, Chung, & Stanton-Chapman, 2010; DiGennaro Reed, Hyman, & Hirst, 2011). One such intervention area that may be

particularly applicable for survivors of pediatric cancer include those that use technology as a primary method of delivery (DiGennaro Reed, et al., 2011). Indeed, cognitive intervention research completed with survivors has indicated that those interventions that require survivors to complete in-person sessions at a medical center may suffer from significant rates of drop-out (Butler, Copeland, et al., 2008). As such, it will be critically important for social functioning interventions designed for survivors to take advantage of technology that will allow survivors to complete these interventions from home.

The technology-based interventions designed for children and adolescents with autism have focused on teaching conversational skills, play skills, or social rules. Very few taught nonverbal social skills, social problem-solving, or emotion identification (DiGennaro Reed, et al., 2011). Unfortunately, it is likely that survivors of pediatric cancer would most likely benefit from interventions that focused on the second group of skills, e.g., nonverbal skills, social problem-solving, and emotion identification. However, it remains to be seen as to whether these skills are teachable, and whether improving them actually influences social adjustment and acceptance.

## *4.3 Conclusions*

The purpose of the current study was to increase understanding of social functioning in survivors of CNS-impacting pediatric cancer. By demarcating the skills that underscore social experience, the current paper sought to provide a direction of inquiry for future research into the social functioning of survivors of pediatric cancer, as well as children in general. Through the initial assessment of an adapted model of social functioning, we were able to identify attention problems and facial expression recognition as key predictors of social experience, and therefore as possible targets for intervention. Indeed, future studies of social functioning should continue to focus on

the assessment of specific neurocognitive and social-cognitive skills, rather than purely on social adjustment. This refocus on skills will further aid the evaluation and understanding of social functioning in survivors of pediatric cancer, and will ultimately contribute to an overall improvement in quality of life.

# Appendix: Tables

**Table 1: Demographic, Diagnostic, and Treatment Information for Survivors of Pediatric Cancer**

| | M ± SD | N (%) |
|---|---|---|
| Age | 12.2 ± 1.69 | |
| Gender | | |
| Male | | 11 (57.9) |
| Female | | 8 (42.1) |
| Race | | |
| Caucasian | | 16 (84.2) |
| African-American | | 1 (5.3) |
| Hispanic | | 1 (5.3) |
| Biracial | | 1 (5.3) |
| Parent Education (years) | 16.0 ± 2.17 | |
| ***Diagnostic & Treatment Information*** | | |
| Diagnosis | | |
| Brain Tumor | | 10 (52.6) |
| ALL | | 9 (47.4) |
| Age at diagnosis | 4.9 ± 2.51 | |
| Treatment | | |
| Surgery | | 9 (47.4) |
| Chemotherapy | | 16 (84.3) |
| Cranial Radiation | | 8 (52.7) |
| Years off-treatment | 5.5 ± 2.38 | |

**Table 2: Demographic Information for Typically-Developing Children and Children with ADHD**

| | Typically-Developing (n = 41) | | ADHD (n = 10) | |
|---|---|---|---|---|
| | M ± SD | N (%) | M ± SD | N (%) |
| Age | 12.0 ± 2.31 | | 12.3 ± 1.95 | |
| Gender | | | | |
| Male | | 20 (48.8) | | 7 (70.0) |
| Female | | 21 (51.2) | | 3 (30.0) |
| Parent Education (years) | 16.0 ± 2.12 | | 15.2 ± 2.38 | |
| Race | | | | |
| Caucasian | | 22 (53.7) | | 3 (30.0) |
| African-American | | 10 (24.4) | | 3 (30.0) |
| Hispanic | | 1 (2.4) | | 1 (10.0) |
| Native American | | 1 (2.4) | | |
| Biracial | | 6 (14.6) | | 3 (30.0) |

**Table 3: Comparisons between Survivors of Cancer and Typically-Developing Children Across Measures: Neurocognitive Skills, Social-Cognitive Skills, and Social Experience**

| | Survivors of Cancer | Typically-Developing | |
|---|---|---|---|
| | M ± SD | M ± SD | *t* |
| **Neurocognitive Skills** | | | |
| Processing Speed[a] | 84.9 ± 14.41 | 100.4 ± 15.78 | -2.90** |
| Working Memory[a] | 96.9 ± 16.24 | 107.1 ± 15.17 | -1.65 |
| Inattention[b] | 59.5 ± 15.74 | 49.4 ± 9.21 | 2.72* |
| **Social-Cognitive Skills** | | | |
| Child Faces z | -0.3 ± 1.26 | 0.4 ± 0.86 | -2.73* |
| FERI Correct | 27.0 ± 4.39 | 29.4 ± 5.33 | -1.60 |
| **Social Experience** | | | |
| Conners' Peer Relations[b] | 59.6 ± 16.88 | 55.8 ± 14.71 | 0.75 |
| CBCL Social Problems[b] | 59.5 ± 8.19 | 53.2 ± 6.17 | 3.22* |
| Emory Dyssemia Index | 84.3 ± 29.3 | 63.9 ± 18.38 | 3.20** |

* criterion $p = .05$ ** criterion $p = .025$

[a] Standard scores: $M = 100$, $SD = 15$
[b] T-scores: $M = 50$, $SD = 10$

For each set of analyses, *p*-values were compared with criterion values calculated according to the Hochberg modified Bonferroni procedure to control for familywise error rate. This procedure requires the ordering of *p*-values from highest to lowest, with the most significant value compared to a criterion alpha value of .05/1 (.05) and the second to an alpha of .05/2 (.025).

**Table 4. Comparisons between Survivors of Pediatric Brain Tumors and Typically-Developing Children Across Measures: Neurocognitive Skills, Social-Cognitive Skills, and Social Experience**

| | Survivors of Brain Tumors | Typically-Developing | |
|---|---|---|---|
| | M ± SD | M ± SD | *t* |
| **Neurocognitive Skills** | | | |
| Processing Speed[a] | 77.5 ± 14.36 | 100.4 ± 15.78 | -3.33* |
| Working Memory[a] | 92.3 ± 11.74 | 107.1 ± 15.17 | -2.14 |
| Inattention[b] | 63.0 ± 14.47 | 49.4 ± 9.21 | 3.24** |
| **Social-Cognitive Skills** | | | |
| Child Faces *z* | -1.1 ± 1.32 | 0.4 ± 0.86 | -3.99* |
| FERI Correct | 24.0 ± 4.34 | 29.4 ± 5.33 | -2.34** |
| **Social Experience** | | | |
| Conners' Peer Relations[b] | 65.3 ± 19.01 | 55.8 ± 14.71 | 1.49 |
| CBCL Social Problems[b] | 62.7 ± 7.93 | 53.2 ± 6.17 | 3.62* |
| Emory Dyssemia Index | 88.1 ± 31.16 | 63.9 ± 18.38 | 2.88** |

* criterion $p = .05$ ** criterion $p = .025$

[a] Standard scores: $M = 100$, $SD = 15$
[b] T-scores: $M = 50$, $SD = 10$

For each set of analyses, *p*-values were compared with criterion values calculated according to the Hochberg modified Bonferroni procedure to control for familywise error rate. This procedure requires the ordering of *p*-values from highest to lowest, with the most significant value compared to a criterion alpha value of .05/1 (.05) and the second to an alpha of .05/2 (.025).

**Table 5: Comparisons between Survivors of Cancer and Children with ADHD Across Measures: Neurocognitive Skills, Social-Cognitive Skills, and Social Experience**

| | Survivors of Cancer | Children with ADHD | |
|---|---|---|---|
| | M ± SD | M ± SD | *t* |
| **Neurocognitive Skills** | | | |
| Processing Speed [a] | 84.9 ± 14.41 | 93.8 ± 17.72 | -1.27 |
| Working Memory [a] | 96.9 ± 16.24 | 93.8 ± 10.94 | 0.49 |
| Inattention [b] | 59.5 ± 15.74 | 78.0 ± 10.42 | -3.18* |
| **Social-Cognitive Skills** | | | |
| Child Faces z | -0.3 ± 1.26 | -0.6 ± 0.85 | 0.56 |
| FERI Correct | 27.0 ± 4.39 | 25.7 ± 2.21 | 0.87 |
| **Social Experience** | | | |
| Conners' Peer Relations [b] | 59.6 ± 16.88 | 66.0 ± 19.88 | -0.82 |
| CBCL Social Problems [b] | 59.5 ± 8.19 | 68.2 ± 12.97 | -2.14* |
| Emory Dyssemia Index | 84.3 ± 29.3 | 100.8 ± 25.70 | -1.48 |

* criterion $p = .05$

[a] Standard scores: $M = 100$, $SD = 15$
[b] T-scores: $M = 50$, $SD = 10$

For each set of analyses, *p*-values were compared with criterion values calculated according to the Hochberg modified Bonferroni procedure to control for familywise error rate. This procedure requires the ordering of *p*-values from highest to lowest, with the most significant value compared to a criterion alpha value of .05/1 (.05) and the second to an alpha of .05/2 (.025)

**Table 6: Correlations Between Measures of Neurocognitive and Social-Cognitive Skills and Social Experience**

| | Neurocognitive Skills | | |
|---|---|---|---|
| | Inattention | Working Memory | Processing Speed |
| Conners' Peer Relations | .36* | -.42* | -.42** |
| CBCL Social Problems | .60** | -.36* | -.31* |
| Emory Dyssemia Index | .70** | -.32$^{+}$ | -.29* |

| | Social-Cognitive Skills | |
|---|---|---|
| | Child Faces *z* | FERI |
| Conners' Peer Relations | -.37* | -.30* |
| CBCL Social Problems | -.45** | -.43** |
| Emory Dyssemia Index | -.38* | -.27* |

$^{+}$ $p < .08$ * $p < .05$ ** $p < .001$

**Table 7. Correlations Between Measures of Neurocognitive and Social-Cognitive Skills and Social Experience for Survivors of Pediatric Cancer**

| | **Neurocognitive Skills** | | |
|---|---|---|---|
| | Inattention | Working Memory | Processing Speed |
| Conners' Peer Relations | .48 | -.49 | -.61* |
| CBCL Social Problems | .64* | -.14 | -.52 |
| Emory Dyssemia Index | .79** | -.24 | -.26 |
| | **Social-Cognitive Skills** | | |
| | Child Faces *z* | | FERI |
| Conners' Peer Relations | -.66* | | -.37 |
| CBCL Social Problems | -.46 | | -.64** |
| Emory Dyssemia Index | -.42 | | -.16 |

* $p < .05$ ** $p < .01$

**Table 8: Regression Models Predicting Social Experience from Neurocognitive and Social-Cognitive Skills**

| | | | **CBCL Social Problems** | | |
|---|---|---|---|---|---|
| | Std β | *SE* | *t* | *F* | $R^2$ |
| | | | | 6.90** | .61 |
| Inattention | 0.44 | 0.10 | 2.94* | | |
| Processing Speed | 0.02 | 0.10 | 0.13 | | |
| Working Memory | -0.19 | 0.11 | -1.24 | | |
| Child Faces *z* | -0.39 | 1.37 | -2.84* | | |
| FERI | -0.25 | 0.36 | -1.81$^{+}$ | | |
| | | | **Conners' Peer Relations** | | |
| | Std β | *SE* | *t* | *F* | $R^2$ |
| | | | | 7.20** | .60 |
| Inattention | 0.34 | 0.15 | 2.39* | | |
| Processing Speed | -0.25 | 0.16 | -1.62 | | |
| Working Memory | -0.15 | 0.16 | -1.00 | | |
| Child Faces *z* | -0.42 | 2.06 | -3.21* | | |
| FERI | 0.00 | 0.55 | 0.00 | | |
| | | | **Emory Dyssemia Index** | | |
| | Std β | *SE* | *t* | *F* | $R^2$ |
| | | | | 15.14** | .72 |
| Inattention | 0.78 | 0.19 | 6.94** | | |
| Processing Speed | -0.18 | 0.20 | -1.44 | | |
| Working Memory | 0.09 | 0.21 | 0.77 | | |
| Child Faces *z* | -0.22 | 2.68 | -2.10* | | |
| FERI | 0.09 | 0.72 | 0.87 | | |

$^{+}$ $p = .08$ * $p < .05$ ** $p < .001$

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## Biography

Victoria "Tori" Watrous Willard was born in Baltimore, Maryland in 1981. She received her Bachelor of Arts degree in Psychology from Washington University in St. Louis in St. Louis, Missouri in 2004. She then took a research assistant position with the Brain Tumor Center at Duke University Medical Center.

Tori entered the doctoral program in Clinical Psychology in the Department of Psychology & Neuroscience at Duke University in 2005. Studying pediatric psychology under the guidance of Melanie J. Bonner, PhD, Tori earned her Master of Arts degree in 2008. Throughout her time at Duke, Tori earned several Conference Travel Awards and a Summer Research Fellowship from The Graduate School to support her research. She also received dissertation funding awards from the Society of Research for Child Development and American Psychological Association Division 38, Health Psychology. While in graduate school, Tori authored or co-authored 14 journal articles, 3 book chapters, and over 30 posters at national conferences. She is a student member of the Society of Pediatric Psychology, the Society for Research in Child Development, and APA Division 38, Health Psychology.

In 2010, Tori began a predoctoral internship in Pediatric Psychology at Nationwide Children's Hospital in Columbus, Ohio. She will begin a post-doctoral fellowship in Pediatric Psychology at St. Jude Children's Research Hospital in Memphis, Tennessee in 2011.