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A Model of Contributors to Academic Achievement Deficits in Childhood Cancer Survivors

Susan Chattin Helton

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Corinna Ethington, Ph.D.
Major Professor

We have read this dissertation and recommend its acceptance:

Ernest A Rakow, Ph.D.

John Smart, Ph.D.

Heather Conklin, Ph.D.

Accepted for the Council:

Karen D. Weddle-West, Ph.D.
Vice Provost for Graduate Programs

A MODEL OF CONTRIBUTORS TO ACADEMIC ACHIEVEMENT DEFICITS IN CHILDHOOD CANCER SURVIVORS

by

Susan Chattin Helton

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I dedicate this dissertation to:

My daughters, Laura Stewart and Katie Chattin, who never stopped believing in their mother.

My mother, Molly Hearn Cox, who gave me the inspiration, especially at the end of her life, to finish what I had started.

To my friends, Beth Gray and Diana Chambers for being my cheering section and for the spiritual support to believe in myself.

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ABSTRACT

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Long-term survivors of childhood cancer often experience a myriad of late effects of their treatment. Among these are academic and learning problems that often do not appear until the child has been off treatment for years. The purpose of this study was to examine the contributors to academic achievement deficits in children who are long-term survivors of acute lymphocytic leukemia (ALL) or a brain tumor (BT), and who have received central nervous system directed treatment. The present study analyzed a hypothesized developmental model of contributors to academic achievement deficits in a sample of 302 long-term survivors. These children participated in a larger study of cognitive late effects and data from that study used in this analysis included: the treatment variables of length of time since completion of treatment, treatment intensity and age when treatment began; demographic variables of gender and age at testing; family education variables; a measure of intelligence; and academic achievement measures in the areas of reading comprehension, basic reading skills, mathematics calculation, mathematics reasoning and spelling. Also included in the analyses were selected items from the Conners' Teacher Rating Scale-Revised: Short form (CTRS-R:S) and the Conners' Continuous Performance Test. Data were submitted to a structural equation modeling analysis. Results of the analyses were generally consistent with the hypothesized model of the causal effects of the treatment-related factors of treatment intensity and age at treatment on academic achievement deficits, however indicated that attention, as measured by the Conners' CPT is not a contributor to these deficits. Length of time off treatment was not found to be a significant contributing variable in the model. Attention and classroom performance problems, as observed by teachers, are significant contributors to academic achievement deficits in this model. The findings also indicated that Intelligence is an important mediating variable in academic achievement outcomes in this sample. Implications of these results for understanding the nature of academic achievement deficits in long-term survivors of childhood cancer, and future assessment and remediation practices are discussed.

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Introduction

Late Effects and the Classroom Issue

While childhood cancer is rare, approximately one in every 350 American children will develop cancer by the time they are 20 years old (Mirro, 2000). The incidence of newly diagnosed cancers has increased by approximately 20 percent over the last 10 years (American Cancer Society, 1997), but survival rates have also increased significantly due to improvements in early detection and treatment (Parker, Tong, Bolden, & Wingo, 1997). Over 75% of children diagnosed with cancer will survive five or more years after diagnosis. In 2003 there were an estimated 270,000 survivors of childhood cancer in the United States with that number expected to rise by another 100,000 over the next decade (Hewitt, Weiner, & Simone, 2003). But this growing population of childhood cancer survivors results in an increase in the number of children who demonstrate a myriad of late effects of their treatment including cognitive and academic problems (Armstrong, Blumberg, & Toledano, 1999; Hudson, 2000; Landier et al., 2004). Along with this increase in survivors with academic problems comes an increase in the need for educational resources to address associated remediation and compensatory issues. Up to 70% of long-term survivors will require some sort of educational assistance in school (Mitby et al., 2003). While a teacher may encounter only a few long-term survivors in his or her teaching career, there is a need for teachers to understand the nature of the academic late effects of these survivors and the appropriate remediation and compensatory strategies for problems. The difficulty is that to date, there have been few studies that focus on the nature of these academic difficulties and remediation strategies, and these studies are essentially limited to controlled clinical or medical settings (Butler & Copeland, 2002; Butler et al., 2008; Conklin, Li, Xiong, Ogg & Merchant, 2008; Patel, Katz, Richardson, Rimer & Kilian, 2009).

Research Focus and Purpose

This study focuses on those influential demographic, treatment and behavioral variables and constructs that are associated with academic achievement success in long-term survivors of childhood cancer. The purpose of this research is to bring together different strands of pediatric cancer and educational research that have not been considered in combination: multidimensional models of academic achievement in children with Attention Deficit/Hyperactivity Disorder and developmental models of the relationship between treatment factors and academic achievement in long-term survivors of childhood cancer. Factors derived from these strands were combined into a theoretical or conceptual model specifying the paths of influence, direct and indirect, to understand how they combine to impact academic achievement success in the classroom in long-term survivors of childhood cancer through the use of structural equation modeling. Background, treatment and psychological factors were used to specify potential paths of influence on academic achievement with reading, mathematics and spelling as indicators of academic achievement success. This model was developed from previously explored theoretical models of cognitive late effects, learning problems and attentional deficits from the educational and pediatric oncology literature with emphasis on teacher observations of classroom behavior and performance. Data from a recently completed study of learning impairments in childhood cancer survivors was used in estimating the model (Mulhern et al., 1999). Thus, the present study seeks to answer the question: What is the causal relationship between treatment variables in long-term survivors of childhood cancer and their academic achievement outcomes as mediated by intellectual, attentional and classroom behavioral factors?

While there have been a number of studies that have explored the academic achievement deficits in long-term childhood cancer survivors, most of them fall short of explaining the nature of the deficits and their impact on day-to-day classroom functioning in these children. The author hypothesizes that a model similar to that presented by Rapport, Scanlan, and Denney (1999) is the most parsimonious explanation of the nature of academic achievement deficits because of the inclusion of information from both standardized testing and teacher observations. Confirmation of the structure of the hypothesized model will increase understanding of the relationship between central nervous system directed treatment factors, deficits in attention as assessed by standardized testing and classroom behaviors, and academic achievement declines. Confirmation of the hypothesized model also will serve to inform the development of classroom based assessments of academic functioning and interventions for long-term survivors of childhood cancer. Understanding the daily classroom functioning of these children is vital in the future development of useful and appropriate intervention strategies for classroom remediation.

Chapter II

Literature Review

Cognitive Late Effects

Nearly one-half of children with cancer will be diagnosed and treated for cancers affecting the central nervous system (Armstrong et al., 1999; Mirro, 2000; Thompson et al., 2001). The most common of these cancers are brain tumors accounting for nearly 20%, and leukemias, accounting for nearly 30% of all childhood cancers, with acute lymphocytic leukemia as the most prevalent type of leukemia (Pui, 2000). It is these two groups of children who are at highest risk for developing cognitive and academic late effects. Research suggests that these cognitive and academic late effects may be caused by the central nervous system directed treatment the children receive. Due to the risk of central nervous system relapse in leukemia and the obvious location of brain tumors, these children are treated with chemotherapy and/or radiation therapy which can be very destructive to brain tissues (Butler & Copeland, 2002; Conklin et al., 2008; Kadan-Lottick et al., 2009; Peterson et al., 2008; Thompson et al., 2001).

With the increased long-term survival of children who have been treated for leukemia or a brain tumor, long-term effects of their treatment have become more apparent. These late effects can occur months or even years following the completion of treatment. Of particular interest since the mid-1970s is the effect of central nervous system directed treatment on cognitive abilities and learning. Studies have focused on the many factors that may contribute to these cognitive late effects, including age at diagnosis, type and intensity of treatment, length of time since completion of treatment and underlying structural changes in the brain.

As early as 1975, studies have focused on the effect of cranial radiation therapy on the cognitive functioning, as defined by IQ, attentional processes and academic achievement success, of children with leukemia. Soni and colleagues (1975) compared the neurocognitive functioning of 34 leukemia patients who received cranial radiation therapy with 27 patient controls just prior to treatment and over the course of 2 years. In this early study, no significant differences were found between the groups in their neurocognitive functioning. These findings, however, have since been refuted in numerous studies. Cousens and colleagues (1988) reviewed 30 comparisons in 20 different studies that reported IQ changes in children who received prophylactic central nervous system directed treatment for leukemia. They submitted their reviews to a meta-analytic procedure to examine the degree and nature of IQ changes in these studies. Their findings indicate that, within this body of research, an average IQ decrement of about two-thirds of a standard deviation, or about 10 points, follows central nervous system prophylaxis that includes cranial radiation therapy. Two main findings were significant for the IQ declines: 1) the age of subjects at the time of diagnosis and irradiation, where declines increased as age at diagnosis decreased; and 2) the time elapsed since diagnosis and cranial radiation therapy, with greater declines occurring as the length of time elapsed.

Brown and Medan-Swain (1993) reviewed 31 studies focusing on cognitive processes of children with leukemia. The survivor studies reviewed consistently suggested that central nervous system prophylaxis, particularly cranial radiation therapy, results in declines in intellectual and neuro-psychological functioning, especially in children who receive treatment at a younger age. However, they noted that many of these studies are flawed in their absence of experimental designs, inadequate statistical analyses, and failure to report confounding variables. In the longitudinal studies reviewed, the data did not support the hypothesis that central nervous system directed treatment results in cognitive declines. Instead, these findings were attributed to confounding variables, non-comparable assessment methods, and lack of adequate controls. Overall, their findings suggest deficits likely exist, but the data were limited in identifying significant deficits.

In an analysis conducted by Moleski (2000) of 33 studies that included children who were diagnosed with leukemia and received prophylactic cranial radiation therapy, significant declines in cognitive functioning were identified in over two-thirds of the studies examined. Further evidence is presented in four of the reviewed studies that suggest children who receive higher doses of intrathecal and systemic chemotherapy may be at a similar risk for decrements in cognitive functioning as those who receive central nervous system directed cranial radiation therapy.

Peterson and colleagues (2008) conducted a meta-analysis of the neuro-psychological sequelae of chemotherapy-only treatment for pediatric acute lymphoblastic leukemia (ALL). Thirteen articles that assessed neuro-psychological and academic functioning differences between children with ALL treated solely with chemotherapy and comparison groups were analyzed using a random effects model, weighted least squares methods. The results support the presence of neuropsychological and academic sequelae for ALL survivors treated solely with chemotherapy in the areas of intelligence, academic achievement, processing speed, verbal memory, fine motor skills and some aspects of executive functioning. Effect sizes in this analysis did not support sequelae in the areas of visual-motor skills and visual memory.

Research also has suggested that different types of chemotherapy received by children with ALL may have differential detrimental effects on neurocognitive functioning. Kaden-Lottick and colleagues (2009) explored the long-term neurotoxicities of two types of CNS prophylactic treatment in a group of 171 children treated for ALL. Eighty-two received intrathecal (IT) methotrexate and 89 received triple IT therapy (i.e., methotrexate with both cytarabine and hydrocortisone). Their results suggest significantly lower Processing Speed Index scores in the children who received IT methotrexate than those who received triple IT therapy. However, in this study both groups performed similarly on tests of intelligence, academic achievement, attention/concentration, memory, and visual motor integration.

Evidence of cognitive late effects in survivors of a childhood brain tumor is much more compelling. Several reviews of the literature have been conducted in the last 40 years that focus on cognitive late effects of treatment, and these all have found evidence suggesting that the type and intensity of cranial radiation therapy, the child's age at treatment, and tumor location are important in determining the degree and nature of cognitive declines. Mulhern, Crisco, and Kun (1983) conducted one of the first literature reviews on the neuro-psychological sequelae of childhood brain tumors. Fifteen studies were reviewed, and while fewer than half reported data on standardized psychological measures, in general, children with brain tumors exhibited a high incidence of intellectual impairment and emotional difficulties. Those exposed to cranial radiation therapy, especially of the whole brain, demonstrated alterations of neuropsychological function. Their review also suggests that young children appear to be at greater risk for cognitive problems, and tumor location plays an important role in the degree of severity of impairment.

Mulhern and colleagues (1992) conducted a subsequent evaluation and critical review of 22 studies involving neuropsychological outcomes of children with a brain tumor. They conducted a multi-study analysis of IQ and found a higher risk for declines in children who received treatment at a young age or who had greater irradiation volume. Specifically, children under 4 years of age who receive cranial radiation therapy appeared to be at greatest risk for decrements in cognitive functioning. Ris and Noll (1993) conducted a similar review of the literature with similar findings of increased risk of cognitive declines in children with a brain tumor, especially in those treated with whole brain radiation therapy at a younger age.

Academic Late Effects

One of the areas of greatest concern in long-term survivors of childhood cancer is their ability to learn at a developmentally appropriate rate. Many of these children are spared problems, but a significant number will experience mild to severe impairments in their ability to learn. Educational achievement in these children may be affected by physical or mental impairments as a result of their disease, subsequent surgery and treatment, lengthy time away from school for treatment and recovery, or emotional distress related to the psychosocial issues with the child and family (Kelaghan et al., 1988). However, a growing number of long-term survivors are experiencing late effects related to difficulties in academic achievement that lead to the need for educational remediation. Mitby and colleagues (2003) analyzed data from 12,430 survivors of childhood cancer who participated in the Childhood Cancer Survivor Study (Robison et al., 2002) on utilization of special education services. Within this cohort, 4,213 participants were treated for leukemia and 1,637 were treated for a brain tumor. Up to 35.9% of leukemia survivors and 70.9% or brain tumor survivors reported using Special Education services with the largest proportion coming from children who were diagnosed prior to age 6 and who received cranial radiation therapy as a part of their treatment. Their findings also suggest that the most common reasons for the need for special education services were low test scores and difficulties with learning and concentration. Over half of these children demonstrated poor test performance, and over 80% exhibited poor learning and difficulty concentrating in class. When compared to sibling controls in this study, the incidence of utilization of Special Education services by long-term survivors was higher with nearly three times as many long-term survivors receiving services as sibling controls.

Academic deficits have been explored in a number of studies, but the results range from no significant deficits to identifying significant academic problems. Studies also have varied in the severity and types of academic deficits identified. Both reading and mathematics disabilities have been reported in this population, but research suggests it is the mathematics deficits that are predominant in both leukemia and brain tumor survivors (Copeland, Fletcher, Pfefferbaum-Levine, Jaffer, & Ried, 1985; Inati et al., 1983; Jannoun, 1983; Peckham, Meadows, Bartel, & Marrero, 1988; Silverman et al., 1984). Brown, Medan-Swain, & Baldwin (1991) compared IQ and academic achievement scores from leukemia patients within the context of federal recommendations, at that time, for specific learning disabilities in mathematics and reading. Results indicated that off-therapy patients who had received a 3-year course of chemotherapy had a significantly higher incidence (nearly 60%) of diagnosable learning disabilities than patients whose treatment had just begun. In a subsequent study by Brown and colleagues (1998) of leukemia survivors who only received chemotherapy as central nervous system prophylaxis found no significant deficits in reading or mathematics achievement. In another study of long-term survivors of pediatric brain tumors, Seaver and colleagues (1994) found academic achievement was significantly impaired in nearly 67% of the children. Although specific treatment variables such as radiation dosage and chemotherapy were not significantly related to achievement deficits, age at treatment was correlated with achievement deficits ($p<0.05$), with children who received treatment at a young age exhibiting more deficits.

In a more recent study by Conklin and colleagues (2008) of academic and behavioral changes after conformal radiation therapy (CRT) in children with localized ependymoma, a type of brain tumor, the researchers found significant declines in reading while math and spelling performance remained stable. They analyzed data from 87 children who were tested six months after treatment, then annually thereafter. Their findings also suggest that male gender, longer symptomatic interval, pre-CRT chemotherapy, pre-existing endocrine deficiencies, hydrocephalus, and younger age at CRT were predictive of a significant decline in reading over time.

Attentional Late Effects

Few studies have explored in depth the causes of academic achievement deficits in long-term survivors of leukemia or a brain tumor. Some studies have suggested that deficits in cognitive functioning and academic achievement may be secondary to attentional deficits that result from central nervous system directed treatment (Butler & Copeland, 2002; Brouwers & Poplack, 1990; Brouwers, Riccardi, & Fedio, 1984; Copeland, deMoor, Moore, & Ater, 1999; Cousens, Ungerer, Crawford & Stevens, 1991; Lockwood, Bell, & Colegrove, 1999; Reddick et al., 2003; Rodgers, Horrocks, Britton, & Kernahan, 1999; Schatz, Kramer, Ablin, & Matthay, 2000). Rodgers et al. (1999) studied the attentional processes of 19 children with leukemia who had received both intrathecal methotrexate and cranial irradiation as part of their treatment regimen, and had completed treatment at least two years prior. Nineteen sibling controls also were studied. The participants received a battery of tests designed to measure various aspects of attention including focus encode, sustain and shift elements of attention. Their results showed a deficient ability to focus and shift attention among patients treated for leukemia when compared with sibling controls. They also found that two thirds of the children with leukemia were described as experiencing difficulty in school. Half of them were receiving extra assistance in the classroom for academic difficulties as compared to only one tenth of the controls. The authors stated that the problems with focusing attention in the children with leukemia had an impact on academic performance because of impaired ability to plan and develop strategic approaches to cognitive tasks.

Etiology of Cognitive and Academic Late Effects

As mentioned before, many of the cognitive late effects of treatment for childhood cancer appear to be related to impaired attention and these attentional difficulties may lead to difficulties in the child’s ability to learn. Studies have suggested a direct relationship between these attention problems and underlying damage to brain tissues caused by cranial radiation therapy and chemotherapy (Mulhern et al., 1999; Reddick et al., 1998; Reddick et al., 2000). Brouwers et al. (1984) studied 23 patients who had undergone treatment for leukemia, and had received cranial radiation therapy and chemotherapy.

Of these patients 10 were found to have normal Computed Tomography (CT) brain scan studies and 13 had abnormal CT scans related to either cortical atrophy or intracerebral calcifications. The group with abnormal scans demonstrated significant problems with attention on a simple auditory reaction time test.

Irradiation to the brain is associated with demyelination and white matter disease, and this damage is thought to impair neural transmission with resultant reduced information processing efficacy (Burger & Boyko, 1991; Butler & Copeland, 2002). Reddick and colleagues (2003) studied the association of normal-appearing white matter on magnetic resonance imaging (MRI) scans to neurocognitive functioning among survivors of pediatric brain tumors. Their results suggest that decreases in normal-appearing white matter are significantly associated with decreases in attentional abilities and IQ. To test for statistical inference, they first computed partial correlation coefficients, controlling for age at radiation therapy and time since completion of radiation therapy in all analyses. Using multiple regression analysis, their final developmental model found that the association between reduced normal-appearing white matter volumes and intellectual deficits can be explained by deficits in memory and attention, and these deficits ultimately result in declines in academic achievement. They found that the model explained approximately 60% (reading, $r^2 = 0.59$; spelling, $r^2 = 0.59$, all $p < 0.001$) of the variance in reading and spelling deficits, and almost 80% ($r^2 = 0.79$, $p < 0.001$) of the variance in mathematics deficits based on declines in standardized achievement test scores.

In a recent study of the relationship between cognitive functioning and white matter volume in the brain in long-term childhood leukemia survivors, Carey and colleagues (2008) compared 9 long-term survivors of ALL with 14 healthy controls. The survivors were treated with chemotherapy only. Voxel-based morphometry (VBM) was used to examine regional grey and white matter differences in both groups and each subject underwent MRI imaging for the VBM analysis. The VBM analysis revealed reduced white matter volume in two areas of the right frontal lobe (i.e., the right middle frontal gyrus and the right superior frontal gyrus) in the long-term survivors of ALL compared to the healthy controls. The ALL group was found to have lower performances on tests of attention, visual-constructional skills, mental flexibility, and math achievement as compared with healthy controls.

Similarities to Attention Deficit Hyperactivity Disorder

Studies have suggested that the attentional impairments seen in long-term survivors of childhood leukemia or brain tumor resemble the pattern of attention problems in children diagnosed with the inattentive type of Attention Deficit/Hyperactivity Disorder (ADHD) (Krull et al., 2008; Lockwood et al., 1999; Rodgers et al., & Kernathan, 1999). Children with the inattentive type of ADHD are characterized by failure to give close attention to details, difficulty sustaining attention in tasks or play activities and difficulty persisting with tasks until completion. They often do not follow through on instructions in the classroom and fail to complete school or homework. In social situations this inattention may be expressed as frequent shifts in conversation, not listening to others or not keeping one's mind on conversations (DSMV-IV; American Psychiatric Association, 1994). In laboratory testing children with ADHD demonstrate difficulties with sustained attention, ability to shift attention, and stimulus discrimination (Klee & Garfinkel, 1983; Losier, McGrath, & Klein, 1996; McGee, Clark, & Symons, 2000; Pineda, Ardila, & Rosselli, 1999). Long-term survivors of childhood leukemia or a brain tumor demonstrate many of these attentional deficits as well. Two studies by Brouwers and colleagues (Brouwers et al.,1984; Brouwers & Poplack, 1990) examined attention in children who had been treated with chemotherapy and cranial radiation therapy for leukemia. The results of these studies suggest that these children had difficulties with sustained attention, reaction time and ability to shift attention. Similar attentional difficulties have been found in long-term survivors of brain tumors (Copeland et al., 1999; Reddick et al., 2003; Riva, Pantaleoni, Milani, & Belani, 1989). Reeves and colleagues (2006) conducted a study of memory and attention deficits in 38 survivors of medulloblastoma, a childhood brain tumor. Their findings suggest a significant relationship between perceptual sensitivity, or stimulus discrimination deficits and lower reading and mathematics performance on standardized testing.

Assessment of Late Effects

The standard for optimal assessment of attentional and academic difficulties has been to include parent and teacher observations of the behaviors. Many educators, clinicians and researchers believe that third party reports are an important source of information regarding the child's behavioral problems and these ratings should be integrated into evaluations whenever possible (Achenbach & Edelbrock, 1978; Bracken & Keith, 2004). Standardized clinical measures are important in the diagnostic process, but do not fully assess the behavioral problems the child is experiencing in the classroom on a daily basis. Teacher observations are invaluable in providing information about the child's difficulties in their natural setting and teacher ratings are the most easily obtained measures of a child’s classroom behavior. Because of the high incidence of academic failure associated with ADHD, teachers are a primary referral source of these children for evaluations, and rating scales have been the predominant method for assessment of ADHD (Atkins & Pelham, 1992; Brown, 1986). Teacher rating scales also have many advantages over other methods of evaluation of learning and behavioral problems. For example, they incorporate the opinions of significant people in the child’s natural environment who are responsible for the care and management of the child, and assist in development of specific, individualized classroom interventions (Barkley, 1988).

Within the pediatric cancer population, the assessment of late effects has been primarily conducted in the laboratory with performance-based measures. Children often undergo extensive neuropsychological batteries to assess deficits in a variety of areas including, but not limited to, cognition, attention, academic achievement, and memory. Few studies have explored the use of rating scales for assessment of these problems and those that have explored these issues have often been limited to small samples and have obtained only minimal information from non-parental sources such as teachers (Noll et al., 1997). Given the importance of parent and teacher ratings in the assessment and remediation of a child’s academic and cognitive problems, it is surprising more emphasis has not been placed on integrating third-party ratings into comprehensive assessment batteries. One reason may be that many of these instruments were developed and validated for use within the ADHD populations but with few other special populations (Hale, How, Dewitt, & Coury, 2001: Kumar & Steer, 2003;

Luk & Lueng, 1989; Moehle & Fitzhugh-Bell, 1989; Parker, Sitarenios & Conners, 1996).

The Conners' Rating Scales have long been popular tools for the clinical assessment of childhood attentional problems with separate parent and teacher checklists specific to home or school situations, respectively (Conners, 1969). While several studies in the pediatric oncology literature have used the Achenbach Child Behavior Checklist (CBCL) (Achenbach & Edelbrock, 1991) as a standard to explore behavior problems in this population (Duval, Braun, Daigneault, & Montour-Proulx, 2002; Fossen, Abranhamsen, & Strom-Mathisen, 1998; Martison & Bossert, 1994; Mulhern, Carpentieri, Shema, Stone, & Fairclough, 1993; Nollet al., 1999; Noll et al., 1997; Schulze-Bonhage et al., 2004; Verrill, Schafer, Vannatta, & Noll, 2000), few studies have reported the use of the Conners' Rating Scales in long-term survivors of childhood cancer (Helton, Corwyn, Bonner, Brown, & Mulhern, 2006; Mulhern, Khan, et al., 2004). Helton and colleagues (2006) explored the factor structure and validity of the Conners' Parent Rating Scale – Revised: Short Form (CPRS-R:S) and the Conners' Teacher Rating Scale – Revised: Short Form (CTRS-R:S) (Conners, 1997) in a sample of 150 long-term survivors of leukemia or a malignant brain tumor who had receive central nervous system directed treatment. Through the use of confirmatory factor analysis (CFA), their findings demonstrated support for the construct validity of the original factor structure of the CTRS-R:S with this sample and suggest that the CTRS-R:S subscale designations are appropriate for the assessment of attentional and cognitive problems in this population. Their initial

CFA findings did not completely support the construct validity of the original factor structure of the CPRS-R:S, but further exploration of more robust goodness-of-fit indices for similar samples sizes, an exploratory factor analysis, and correlations between the subscales of the CPRS-R:S and the relevant subscales of the CBCL suggested the CPRS-R:S may be adequate for use within this population.

Chapter III

Models of Attention and Academic Achievement

Rapport and colleagues (1999) hypothesized a dual pathway model of school behavior and select cognitive abilities that serve as important mediators between attention deficit, intelligence, and later academic achievement (Figure 1). They found significant relationships between ADHD symptoms and scholastic achievement by dual pathways. One pathway is described as a behavioral pathway which is comprised of behavioral variables as reported by teachers. In this behavioral pathway the latent variable termed “classroom performance” was derived from measured variables related to academic success (AS), academic productivity (AP), and academic efficiency (AE). The other pathway is described as a cognitive pathway which is comprised of cognitive variables. This pathway consists of two latent constructs, vigilance and memory, which are derived from standardized test measures of attention and memory conducted in a clinical setting. The higher order latent construct of vigilance is comprised of two distinct Continuous Performance Test (CPT) paradigms related to the automatic mode of information processing (AX) and the more difficult controlled process paradigm (BX). AX and BX are first order latent variables comprised of the percentage of correct identifications of low (L) and high (B) target density versions of the CPT. The latent construct of memory is derived from three two-block combinations (B12, B34, B56) of a paired associations learning task.

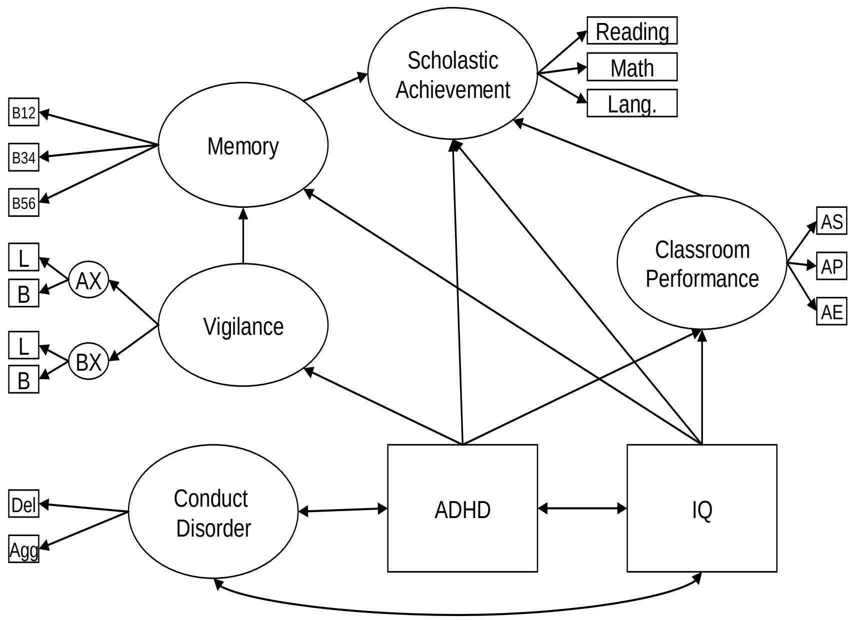

Figure 1. Fitted Dual Pathway Model of ADHD and Scholastic Achievement. Adapted from "Attention-Deficit/Hyperactivity Disorder and Scholastic Achievement: A Model of Dual Developmental Pathways," by M. D. Rapport, S. W. Scanlan, and C. B. Denney, 1999, *Journal of Child Psychology and Psychiatry, 40*, p. 1178. Copyright 1999 by the Association for Child Psychology and Psychiatry.

Reddick and colleagues (2003) hypothesized a developmental model of the relationship between changes in the normal appearing white matter in the brain (NAWM), attention, memory, intelligence and academic achievement (Figure 2) in long-term survivors of a pediatric brain tumor who had received central nervous system directed treatment. Their findings suggest that post-therapy changes in the NAWM in the brain relate to subsequent deficits in attention abilities, which then result in decreased IQ and ultimately academic achievement deficits.

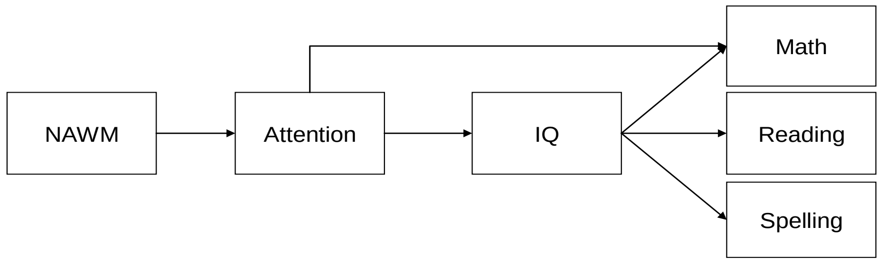

Figure 2. Developmental model relating normal-appearing white matter (NAWM) to academic achievement through attention and intelligence (IQ). Adapted from "Developmental Model Relating White Matter Volume to Neurocognitive Deficits in Pediatric Brain Tumor Survivors," by W. E. Reddick, H. A. White, J. O. Glass, G. C. Wheeler, S. J. Thompson, A. Gajjar, L. Leigh, and R. K. Mulhern, 2003, *Cancer*, 97, p. 2513. Copyright 2003 by the American Cancer Society.

Other developmental models have been proposed using variables such as treatment and background characteristics with childhood cancer survivors (see Schatz et al., 2000). While these models explore the relationships between treatment and cognitive outcomes, they fall short of exploring behaviors that are vital to a child's success in the classroom. The hypothesized model merges the works of Rapport et al. (1999) and Reddick et al. (2003) in the study of the nature of academic achievement deficits in the classroom. The hypothesized model estimates both the direct and indirect effects of factors chosen to estimate the behavioral and cognitive constructs of the Rapport et al. (1999) ADHD-IQ-Achievement portion of their dual pathway model for academic achievement deficits while accounting for the influences of treatment and background variables that contribute to post-therapy changes in the brain as proposed by

Reddick et al. (2003). Because both behavioral and cognitive components have not been considered together in a previous study of long-term survivors of childhood cancer as an explanation academic achievement deficits, this hypothesized model is unique.

Chapter IV

Empirical Model of Attributes to Academic Achievement Deficits

The Hypothesized Model

As derived from the Rapport et al. (1999) and Reddick et al. (2003) models, the hypothesized dual pathway model for the present study explores the relationship between the ADHD, inattentive type symptomotology and academic achievement outcomes as mediated by classroom and academic behaviors. As reported earlier, well established research findings support the premise that central nervous system directed treatment factors in pediatric cancer survivors have a significant relationship to the varying degrees of deficits in academic achievement and these variables were included in the hypothesized model. Additionally, the hypothesized model explored the relationship among deficits in attention, IQ and academic achievement within the framework of the influence of treatment factors. Because of the importance of teacher observations in assessing the classroom behaviors of inattention and poor performance, and the necessity of identification of specific causes of academic achievement deficits in long-term survivors of childhood cancer with both objective and subjective data, teacher ratings of behavior along with clinical measures allow for a thorough exploration of achievement deficits in this study.

Indicator variables and factors to be estimated by the measurement model of the hypothesized study are outlined in Table 1 and illustrated in Figure 3. An overview of the indicator variables and each factor to be estimated follows. The illustrated model outlined in Table 1 represents the constructs associated with the psychological and behavioral aspects of a theoretical framework derived from the works of Rapport et al. (1999) and Reddick et al. (2003).

Table 1

Variables and Factors to be Estimated by the Structural Model of Contributors to Academic Achievement Deficits

Variables for Demographics:
- Age at Testing
- Gender
- Family Education (As single scale derived from Mother's Education and Father's Education)

Variables for Treatment:
- Age at Initiation of Treatment
- Treatment Intensity
- Months since completion of treatment at time of testing

Factor	Construct Content
I. ADHD/Inattentive Type	Teacher observations of the child's attention in the classroom
II. IQ	Global estimate of the child's cognitive functioning
III. Attention	Clinical assessment of the child's vigilance and sustained attention
IV. Classroom Performance	Teacher observations of the child's everyday functioning in academic skills in the classroom
V. Academic Achievement	Clinical assessment of the child's academic skills attainment

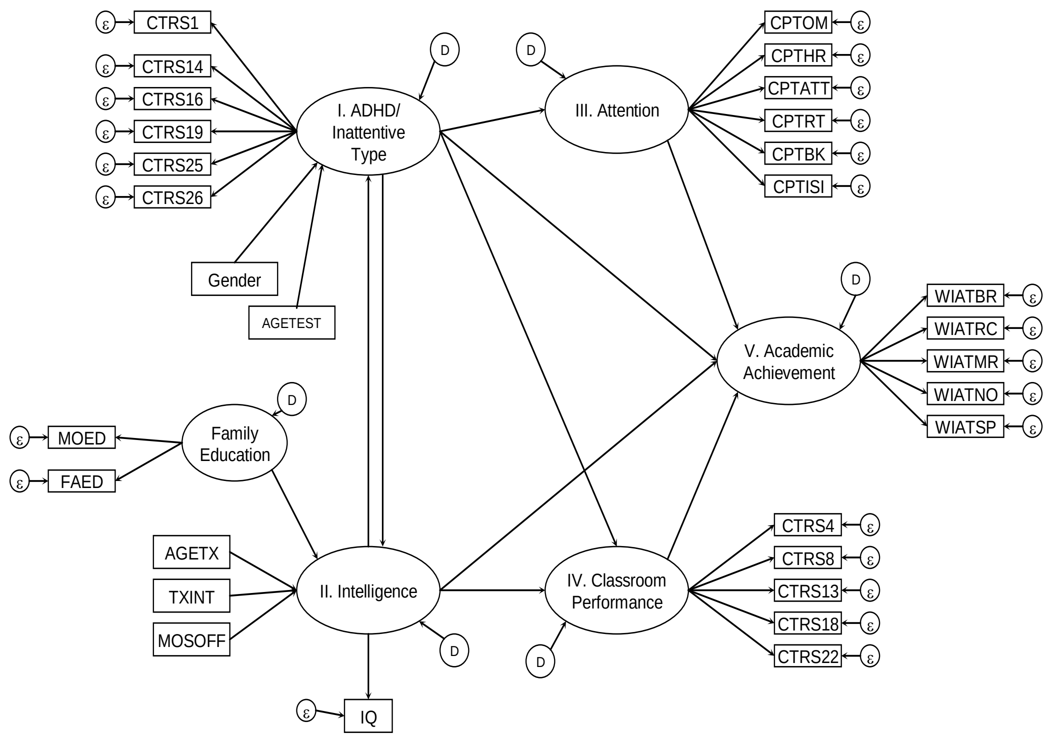

Figure 3. Hypothesized Model of Contributors to Academic Achievement Deficits in Long-Term Survivors of Childhood Cancer. Note. AGETEST = Age at Testing; Gender = Gender; MOED = Mother's Education; FAED = Father's Education; AGETX = Age at Treatment; TXINT = Treatment Intensity; MOSOFF = Months off Treatment; IQ = WISC IQ; CTRS1 – CTRS26 = Questions from the Conners Teacher Rating Scale – Revised: Short Form; CPTOM = Conners CPT Omissions; CPTHR = Conners CPT Hit Rate; CPTATT = Conners CPT Attentiveness; CPTRT = Conners CPT Risk Taking; CPTBK = Conners CPT Block Change; CPTISI = Conners CPT Interstimulus Interval Change; WIATBR = WIAT Basic Reading; WIATRC = Wechsler Individual Achievement Test (WIAT) Reading Comprehension; WIATMR = WIAT Math Reasoning; WIATNO = WIAT Numerical Operations; WIATSP = WIAT Spelling
* $P < .05$.

Discussion of the Hypotheses and Proposed Paths

The hypothesized dual pathway model in this study is derived from well established findings from both the ADHD and pediatric oncology literature, and the following paths are hypothesized to be significant. Guided by these models, a developmental model of contributors to academic achievement outcomes in long-term survivors of childhood cancer is hypothesized to account for the relationship between CNS treatment variables, attention deficit behaviors and academic achievement.

The student's observed classroom performance is expected to directly affect the child's level of academic achievement, as is the objective assessment of the child's attention. The child's level of attentive behavior in the classroom is expected to have a direct affect on the objective measure of attention and the child's observed daily classroom performance. The child's level of attentive behavior in the classroom is also expected to have a direct affect on academic achievement and is expected to have an indirect affect as mediated by objective measure of attention. The child's level of attentive behavior is expected to be directly affected by the child's background and the child's treatment status. IQ is expected to have a direct affect on academic achievement and on classroom performance, and is expected to have an indirect influence on academic achievement as mediated by classroom performance. IQ is also expected be directly affected by the child's background and the child's treatment status. Additionally, the latent construct representing child's level of attentive behavior in the classroom is expected to be highly correlated with the child's IQ with correlated latent construct residuals and no directional path of causality between these constructs.

In Figure 3, paths are drawn to illustrate the hypothesized paths of direct and indirect causation. These paths follow the logical temporal sequence of events that ultimately contribute to the level of the child's academic achievement that is based on previous empirical findings in the literature. Within a construct, such as Classroom Performance or Attention, one or more factors were estimated as components of this construct. Single variables, such as gender or age at treatment, are included in the model as predisposing factors that are hypothesized to be influential on the hypothesized latent constructs, and ultimately through indirect paths, on achievement.

Overview of Background Measures.

Student Background Variables. Three exogenous variables representing the student's background demographics are included in the model: Age in years of the child at the time of testing, gender, and family education. Family education is a scale derived from the mother's and father's education. Gender difference findings in the ADHD literature have been mixed (Brown, Medan-Swain, & Baldwin,1991).

Few studies have explored gender differences in the prevalence or severity of academic late effects in long-term cancer survivors, although a number of these studies suggest their findings may be influenced by gender differences and suggest further exploration in more comprehensive studies (Brown et al., 1998, Ris & Noll, 1993). Numerous studies have found associations between parental education and IQ within both the educational and pediatric cancer literature (Pastor & Reuben, 2002; Velting & Whitehurst, 1997). Because age adjusted scores are not used on all of the measures, the child's age at testing is used to control for the influence of age effects between observed behavioral and academic outcomes.

Treatment Variables. Three exogenous variables representing the treatment factors of the subjects are included in the model: Age in years of the child at the time central nervous system treatment began, treatment intensity, and number of months since completion of all treatment for either leukemia or a brain tumor. The treatment intensity is defined as either low intensity (chemotherapy only) or high intensity (cranial irradiation therapy with or without chemotherapy). Numerous study findings indicate that the younger the child is when beginning central nervous system directed treatment, the more intense the treatment and greater length of time since the completion of treatment all have a significant impact on the development of attention, IQ, and academic deficits in long-term survivors of childhood cancer (Ris & Noll, 1993).

Overview of Factors Estimated and Construct Content

Attention Deficit Hyperactivity Disorder (ADHD)/ Inattentive Type. This construct is an indication of observed inattentiveness in the classroom. In the studies of attentional problems in long-term survivors of childhood cancer, results consistently suggest these children are most similar to children diagnosed with the inattentive type of Attention Deficit Hyperactivity Disorder (Mulhern et al., 2004; Reeves et al., 2006). The items used in the hypothesized model were subjected to a confirmatory factor analysis by Helton et al. (2006) and were found to be important in the measurement of this construct as indicated by goodness-of-fit indices.

The ADHD/Inattentive construct is represented by the teacher's perceptions of the child's ability to attend from moment to moment, and to sustain that attention throughout the lesson. Only those items from the Conners' Teacher Rating Scale - Revised: Short Form (CTRS-R:S) specific to attention in the classroom have been used as indicators of the effects of treatment on the child's attentional functioning on a daily basis with the premise that a child's daily functioning is ultimately a predictor of long-term academic achievement.

Intelligence. This is a single variable construct derived as an estimate of the child's cognitive abilities. A number of studies have explored the relationship between treatment, IQ and academic achievement (Brown & Medan-Swain, 1993; Ris & Noll, 1993). Both Reddick and colleagues (2003), and Rapport and colleagues (1999) include IQ in their models of academic achievement outcomes.

Because global intelligence has been well established as an important predictor of a child's level of academic achievement, IQ has been included in the model to control for variability in achievement outcomes. It's placement in the model has been guided by the relationships found in the Reddick et al. (2003) model of treatment related influences on IQ and achievement outcomes in long-term survivors of childhood cancer.

Attention. This is an indicator of measured attention in a clinical setting. The usefulness of clinical measures of attention has been widely reported as part of a multi-modal approach to the diagnosis of learning problems in the classroom. Continuous performance tests measuring various aspects of attention have received substantial support in the literature (Losier et al., 1996). Klee et al. (1983) found significant correlations between a continuous performance task and teacher measures of attention in the classroom. However, a few studies have questioned the sensitivity of this type of measure. A study by McGee and colleagues (2000) failed to find significance in the correlations between teacher ratings of attention in the classroom and clinical administration of a continuous performance test. In both the Reddick et al. (2003) and Rapport et al. (1999) models, attention, as measured by a continuous performance task, was shown to have direct and indirect effects on academic achievement.

In order to provide an objective measure of the child's vigilance and attention, the Attention construct is derived from those most clinically relevant measures on the individually administered Conners' Continuous Performance Test (CPT) (Conners, 1995) of immediate and sustained attention as measured by a computerized clinical test given to the child. These include measures of number of omissions, hit reaction time, attentiveness, risk taking, and changes in reaction time between individual stimuli and blocks of stimuli. Vigilance and attention, within the context of this study refers to the child's ability to attend and respond appropriately to a stimulus and to sustain that attention over time.

Classroom Performance. This is a multifaceted construct of a child's daily academic performance in the classroom and includes a variety of behaviors such as difficulty in various academic subjects, retention of learned material, and the child's interest and motivation in learning. Second party observations are well established tools in validating clinical findings of the presence of learning problems. While numerous studies report parental ratings of behavior in long-term survivors of childhood cancer, few studies explore teacher ratings of classroom behaviors. Including teacher ratings in the assessment of behavior in children, and their utility in a comprehensive exploration of academic achievement success or failure, however, is vital (Brown, 1986). The items used in the hypothesized model were subjected to a confirmatory factor analysis by Helton et al. (2006) and were found to be important in the measurement of this construct as indicated by goodness-of-fit indices.

The latent variable of Classroom Performance consists of items from the CTRS-R:S relevant to the child's functioning in mathematics, reading and spelling on a daily basis as perceived by that child's teacher relative both to other students in the class and to age expectancies. Items related to forgetfulness and lack of interest are included as indicators of the child's competency and mastery in academics, and their relationship to overall classroom performance. The rationale is that if a child forgets what he or she has learned, then mastery of that topic is not optimal. In addition, lack of interest within the context of this model is an indicator of the child's losing interest in academics because the skills are too difficult to master.

Academic Achievement. This is the ultimate dependent construct of this study. This construct consists of clinical measurement of the extent to which a child has learned or mastered academic skills at an age appropriate level. Academic achievement scores differ from measures of classroom performance, although the two are clearly related. The construct of academic achievement, within the parameters of this model and as used by both Reddick et al. (2003)

and Rapport et al. (1999), is a latent variable derived from reading, mathematics and language measures.

The latent construct of Academic Achievement is indicated by the child's performance on the Wechsler Individual Achievement Test (WIAT) (Psychological Corporation, 1992) relative to age related peers in five areas of academics that include basic reading, reading comprehension, mathematics reasoning, numerical operations and spelling. Within this model it is parsimonious to group these areas together as an indicator of the child's overall success in learning as predicted by the influence their central nervous system directed treatment for cancer has had on variables that have been shown to influence academic achievement outcomes.

Chapter V

Methodology

Data Source and Description

The data for this study will be drawn from an IRB approved, multi-site, two phase study of learning impairments in long-term survivors of childhood cancer. Specifically, the first phase (screening) of the study was designed to explore the nature of academic achievement deficits that are considered to be late-effects of the child's treatment for cancer. The first phase focuses on the impact factors such as age at treatment, intensity of treatment, and time since treatment have on the child's white matter volume in the brain as well as on IQ, academic achievement, attention and everyday psychosocial functioning at home and in the classroom. The second phase (treatment) of the study explores the use of medication in the treatment of significant attentional and academic achievement deficits found in the test battery administered during the screening phase. The ultimate goal of this phase is to determine the efficacy of medication on long-term improvements in learning. The study began in January 2000 and spans more than eight years of data collection with continued accrual at the beginning of this study. The target accrual for the screening phase is 625 children with up to 150 participating in the treatment phase (Mulhern et al., 1999).

Participants

The participants for this study included 311 school-age children who are long-term survivors of either leukemia or a brain tumor, and who have received central nervous system directed treatment. Only the data of participants from one site of the multi-site study were used due to their completeness and IRB approval restrictions. All of the participants are at least one year post-completion of their treatment and have no evidence of progressive or recurrent disease. The data from these participants will be obtained from the screening phase of a larger sample of subjects participating in the previously mentioned study of learning impairments in this population. All of the participants in this study are between the ages of 6 and 18, have no diagnosis of ADHD prior to the treatment for their cancer, and have complete testing data. Written Informed consent for each subject was obtained from parents and/or legal guardians prior to any assessment and assent from all children over the age of 14.

Evaluation Measures

The measures available and item scoring are outlined in Table 2 and described below:

Table 2

Items Used in Measuring Exogenous and Endogenous Constructs

Factor	Study Variables	Item Scoring
Student Background	Age at testing	Range = 6.0-18.9 years
	Gender	0 = Male 1 = Female
	Mother's Education	1 = Did not complete high school 2 = Completed high school/GED 3 = Some College/technical degree/Assoc. degree 4 = Bachelor's degree 5 = Graduate degree
	Father's Education	1 = Did not complete high school 2 = Completed high school/GED 3 = Some College/technical degree/Assoc. degree 4 = Bachelor's degree 5 = Graduate degree

(table continues)

Table 2 (cont.)

Items Used in Measuring Exogenous and Endogenous Constructs

Factor	Study Variables	Item Scoring
Treatment Status	Age at treatment	Range = 0.0 to 17.9 years
	Treatment Intensity	1 = Mild Intensity - chemotherapy only 2 = High Intensity - chemo. and/or radiation therapy
	Months off treatment at time of testing	Range = 12 to 215
ADHD/Inattention	Conners' Teacher Rating Scale Items 1 - "Inattentive, easily distracted 14 - "Short attention span" 16 - "Only pays attention to things he/she is really interested in" 19 - "Distractibility or attention span a Problem" 15 - "Does not follow through on instructions and fails to finish schoolwork"	All Items 0 = Not True At All (Never, Seldom) 1 = Just A Little True (Occasionally) 2 = Pretty Much True (Often, Quite A Bit) 3 = Very Much True (Very Often, Very Frequent)
IQ	Wechsler Intelligence Scales	Range = 40 to 160 (Std. Score)
Attention	Conners' Continuous Performance Test Sustained attention indices Omissions Hit Reaction Time (RT) Attentiveness Risk Taking Hit RT Block Change Hit RT Interstimulus Interval Change	All indices Range = 1 to 99 (T Score)
Classroom Performance	Conners' Teacher Rating Scale Items 4 - "Forgets things he/she has already learned" 8 - "Poor in spelling" 13 - "Not reading up to par" 18 - "Lacks interest in schoolwork" 22 - "Poor in arithmetic"	All Items 0 = Not True At All (Never, Seldom) 1 = Just A Little True (Occasionally) 2 = Pretty Much True (Often, Quite A Bit) 3 = Very Much True (Very Often, Very Frequent)
Academic Achievement	Wechsler Individual Achievement Test Subtests Basic Reading Reading Comprehension Spelling Mathematics Reasoning Numerical Operations	Range = 40 to 160 (Std. Score)

Conners' Teacher Rating Scale-Revised: Short Form (CTRS-R:S). The Conners' Teacher Rating Scale – Revised: Short Form (CTRS-R:S) (Conners, 1997) was used to assess participant's attention and classroom performance at school. The Conners' Rating Scales – Revised: Short Forms (CRS-R:S) were developed from the most clinically useful subscales (Oppositional, Cognitive Problems/ Inattention, Hyperactivity) of the Conners' Rating Scale – Revised: Long Form (CRS-R:L) for use when multiple administrations over time were desired. Each of the three subscales contains items with the highest loadings from an exploratory factor analysis of the items on the CRS-R:L. A fourth subscale, the ADHD index, also was included for assessing children and adolescents with ADHD symptoms based on the Diagnostic and Statistical Manual for Mental Disorders, Fourth Edition (DSM-IV) (Conners, 1997; American Psychiatric Association, 1994). This fourth subscale was not included in Conners' initial exploratory factor analyses (EFA), but was later added to facilitate the clinical diagnosis of ADHD. The CRS-R:S includes the 28-item teacher (CTRS-R:S) form. Sample items from the four subscales on the teacher form includes: "Defiant" and "Loses temper" (Oppositional subscale); "Fails to complete assignments" and "Not reading up to par" (Cognitive Problems/Inattention subscale); "Restless in the 'squirmy' sense" and "Excitable, impulsive" (Hyperactivity subscale); and "Short attention span" and "Distractibility or attention span a problem" (ADHD Index subscale; Conners, 1997). Each item is scored on a scale of 0 to 3 with 0 as "Not True at All" up to 3 as "Very Much True."

A number of studies have explored the validity and reliability of the CTRS-R:S within both general and special populations. To confirm the three-factor model (Oppositional, Cognitive Problems/Inattention, and Hyperactivity subscales) for the CTRS-R:S, Conners (1998) tested the 17 items on the CTRS-R:S using confirmatory maximum likelihood factor analysis. Conners' findings suggest that the CTRS-R:S met the criteria for adequacy of fit to the three-factor model. Hale, How, Dewitt and Coury (2001) conducted a study exploring the validity of the CTRS-R:S and found adequate support for the discriminant validity of the measures within the ADHD population. Helton and colleagues (2006) tested the factor structure proposed by Conners' in a sample of long-term survivors of childhood cancer and found that the CTRS-R:S met the criteria for adequacy of fit to Conners' proposed model.

Wechsler Intelligence Scales (WISC-III & WAIS-R) In order to derive an estimate of intelligence all participants were given a short form of the test that included the Information, Similarities, and Block Design subtests from either the Wechsler Intelligence Scale for Children – Third Edition (Psychological Corporation, 1997) or Wechsler Adult Intelligence Scale – Revised (Psychological Corporation, 1989). The Wechsler Intelligence Scale for Children – Third Edition (WISC-III) and Wechsler Adult Intelligence Scale – Revised (WAIS-R) are commonly used standardized measures of intelligence with the WISC-III used for children ages 6 to 16 years of age. Each measure, in its complete form, yields a Verbal Scale IQ, a Performance Scale IQ, and a Full Scale IQ. Various short forms of the WISC-III and WAIS-R often are administered to derive estimates of IQ when time restraints and test fatigue are factors. The short form of the measures using the Information, Similarities and Block Design subtests are accepted as adequate for estimation of intellectual abilities with good reliability (.92) and validity (.87) for both the WISC-III and WAIS-R (Sattler, 2001). The total estimated IQ score is a standard score with a mean of 100 and standard deviation of 15.

Wechsler Individual Achievement Test (WIAT). All participants were administered the five subtests related to reading, mathematics and spelling subtests of the Wechsler Individual Achievement Test (WIAT) (Psychological Corporation, 1992). The WIAT is a comprehensive battery for assessing academic achievement of children in Grades K through 12 and 5 to 19 years of age. Two subtests, Basic Reading and Reading Comprehension, comprise the Reading Composite, and two subtests, Mathematics Reasoning and Numerical Operations, comprise the Mathematics Composite score. A fifth subtest, Spelling, also is administered. This test results in age-corrected standard scores based upon a large normative sample for Basic Reading, Reading Comprehension, Spelling, Numerical Operations, and Mathematics Reasoning achievement that will be used in the quantitative analyses. The WIAT was standardized using the same sample as the WISC-III. The subtests and Composite Scores are standard scores with a mean of 100 and a standard deviation of 15.

Conners' Continuous Performance Test (CPT). All participants were administered the Conners' Continuous Performance Test (CPT) as a measure of attention (Conners, 1995). The CPT is a computerized measure of attention and concentration that assesses an individual's ability to sustain attention, provides an estimation of processing speed, and identifies deficits in stimulus discrimination. The respondents are required to discriminate targets (i.e., X's) from non-targets (i.e., letters of the alphabet) at varying intervals of time between presentations of each stimulus. Eleven age- and gender-corrected indices of attention are derived from the respondents' patterns of responses. For the present study, the indices for Errors of Omission, Attentiveness, Risk Taking, Hit Reaction Time, Hit Reaction Time Block Change and Hit Reaction Time Interstimulus Interval Change were used as indicators of the participant's stimulus discrimination abilities and processing speed. The scores for Errors of Omission are presented as percentile rank scores. The Conners CPT does not generate T scores for this index. The scores for the remaining indices are presented as T Scores with a mean of 50 and a standard deviation of 10.

Statistical Analyses

Structural equation modeling (SEM) is a statistical methodology that takes a confirmatory approach to the analysis of causal models of multiple variables. It is a technique that allows the researcher to specify *a priori* the relationships among variables used in the model and to estimate models of linear relationships among those variables, both measured and latent, that can then be tested statistically in a simultaneous analysis of the entire system of variables. SEM has its advantages over other multivariate procedures. It permits the simultaneous estimation of both direct and indirect paths. As stated previousely, it is a confirmatory rather than an exploratory approach to data analyses. It also lends itself well to the analysis of data for inferential purposes because the pattern of intervariable relations are specified *a priori*. Most other multivariate methods, other than path analysis, are descriptive in nature and do not allow for inferential or causal relationships to be tested. (Byrne, 2001). Within the realm of observational studies, SEM is used primarily for two types of designs: cross-sectional and longitudinal. While, for the purposes of this study, a cross-sectional design will be utilized and discussed, the hypothesized model implies a temporal and developmental sequence to the hypothesized paths of influence.

Prior to estimating the hypothesized model, data was analyzed for outliers, normalcy of the distributions and variance using PASW 18 (SPSS, Inc., 2009). Because mixed data (i.e., variables scaled as categorical, ordinal and continuous) are used in this model, any extreme skewness in the distribution of the data for each variable, or differential skewness among the variables may influence the results of the analyses. A high degree of skewness in the distributions may inflate the χ^2 values and underestimate the error variance estimates. If the distributions appear to be problematic, this will be considered in the interpretation of the goodness-of-fit indices.

Measurement Model. The measurement model for this study was assessed with AMOS 18 (Arbukle, 2009) using maximum likelihood estimates derived from covariance matrices. The parameter estimates were evaluated for feasibility and statistical significance, and the standard errors for appropriateness. Then global and incremental fit indices were used to evaluate the extent to which the hypothesized models adequately describe the data.

AMOS 18 allows for analyses to be carried out for observed variables that are continuous, ordinal or nominal as represented in the hypothesized model. Multiple absolute and incremental fit indices were used to evaluate the extent to which the hypothesized measurement model accounted for observed relationships among variables:

(1) Root Mean Square Error of Approximation (RMSEA; Browne & Cudek, 1993) represents the average difference between correlations observed among measured variables and those expected on the basis of a model's assumptions. Values falling below 1.0 suggest adequate fit (Kline, 1998).

(2) Normed Fit Index (NFI; Bentler & Bonett, 1980) indicates the proportion in the improvement of the overall fit of the model relative to a baseline null model. Values range between 0.0 and 1.0 with results close to 1.0 indicated adequate fit (Bentler 1992).

(3) Incremental Fit Index (IFI; Bollen, 1989) addresses parsimony and sample size with values close to 1.0 indicating adequate fit (Bollen, 1989).

(4) Comparative Fit Index (CFI; Bentler, 1990) takes into account sample size and is derived from a comparison of the hypothesized model with the independence model. Values close to 1.0 indicate adequate fit (Byrne, 1998).

(5) Relative Fit Index (RFI; McDonald & Marsh, 1990) is equivalent to the CFI with values close to 1.0 indicating adequate fit (Byrne, 1998).

(6) Tucker-Lewis Coefficient also is known as the non-normed fit index (NNFI). Values close to 1.0 indicate adequate fit (Bollen, 1989).

Structural model. Once the measurement model was tested through CFA using AMOS 18, the full latent variable model was estimated to specify the regression structure among the latent variables. The initial model was estimated with each endogenous variable regressed on all exogenous variables and causally antecedent endogenous variables. All possible paths were estimated to test whether the paths hypothesized to be zero are non-significant. To test for reciprocity between the constructs of ADHD/Inattention and Intelligence, the model was analyzed by constraining ADHD/Inattention and freeing Intelligence, then repeating the procedure by constraining Intelligence and freeing ADHD/Inattention to determine which has the stronger relationship.

Post hoc analyses were conducted, based on the results from the initial analyses, to test for multicollinearity and to estimate the final model. Variables with very low reliability were omitted and the analyses were run to test the improved model.

Chapter VI

Results

The model was run for all participants who had complete data. The original sample included 311 subjects. Ninety-seven percent had completed data, leaving 302 subjects to be included in the analysis. Analysis of the deleted subjects indicated no specific pattern of missing data. Table 3 shows the demographic characteristics of the sample.

Table 3

Demographic and Medical Variables for the Sample (n = 302)

Variable		
	Mean (SD)	Range
Age at testing (years)	11.9 (3.35)	6-18
Age at treatment (years)	5.3 (3.2)	.24-15.5
Months off treatment	58.4 (36.8)	12-166
	Frequency	Percent
Gender		
Male	167	55.0
Female	135	45.0
Parent Education		
Father's Education		
Did not complete high school	31	10.3
Completed high school	111	36.7
Some college/technical school	80	26.5
Completed undergraduate degree	51	16.9
Completed graduate degree	29	9.6
Mother's Education		
Did not complete high school	29	9.6
Completed high school	109	36.1
Some college/technical school	92	30.5
Completed undergraduate degree	52	17.2
Completed graduate degree	20	6.6
Treatment Intensity		
Mild - Chemotherapy only	146	48.3
High - Radiation therapy with or w/o chemo.	156	51.7

Analysis of the data for outliers and distribution indicated the distributions for age at treatment, months off treatment, IQ, and all of the WIAT achievement scores (i.e., basic reading, math reasoning, etc.) were relatively normal with no problems with skewness or kurtosis. Analyses of the data for the Conners' CPT indicated the distributions for the five of the six indices were not normal with evidence of clusters of scores close to the mean and a leptokurtotic distribution. Multicollinearity statistics were within acceptable range.

The parameter summary and goodness-of-fit statistics related to the contributors to academic deficits model are presented in Tables 4 and 5. As displayed in Table 4, there are 68 regression weights; 34 are fixed to 1 (22 in error terms, 6 disturbance terms, and 6 factor loadings) and 34 are estimated. There are 36 variances, all of which are estimated, and there is no covariance to estimate. In total, there are 141 parameters, 107 of which are to be estimated. The required sample size for this study, taking the lower-bound requirement of Bentler and Chou's (1987) rule of thumb, will be 5 x 110 = 550, and the upper bound will be 10 x 110 = 1100. The sample size of 302 for this study is below the lower-bound recommendation, indicating that the results of this analysis may be affected by low statistical power.

Table 4

Parameter Summary for the Contributors to Academic Deficits Model

Parameter	Weights	Covariances	Variances	Means	Intercepts	Total
Fixed:	34	0	0	0	0	0
Labeled:	0	0	0	0	0	0
Unlabeled:	34	10	36	5	22	107
Total:	68	10	36	5	22	141

Initial data analyses indicated low reliabilities for three of the Conners' CPT measures (Hit Reaction Time, -.20; Block Change, .19; Interstimulus Interval Change, .27). These were omitted from the model and the analyses re-run. Model fit improved with the omission of the three variables.

Overall, the fit statistics for the model showed an adequate fit of the model to the data. Chi-square statistic (χ^2) of the model was significant (1067.536/df=304, *p*=.000). With this sample all goodness of fit indices met the criteria for and adequate fit of the model to the data (RMSEA = 0.091, CI = 0.085-0.097; NFI = 0.83; RFI = 0.80; IFI = 0.87; TLI = .85; CFI = 0.87).

Table 5

Goodness-of-Fit Statistics for the Contributors to Academic Achievement Deficits Model

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	101	1067.536	304	.000	3.512
Saturated model	405	.000	0		
Independence model	54	6125.217	351	.000	17.450

Model	NFI	RFI	IFI	TLI	CFI
Default model	.826	.799	.869	.847	.868
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.091	.085	.097	.000
Independence model	.234	.229	.239	.000

Note. Abbreviations: NPAR = number of parameters, CMIN = minimum discrepancy; NFI = normed fit index; RFI = relative fit index; IFI = incremental fit index; TLI = Tucker-Lewis coefficient; CFI = comparative fit index; RMSEA = root mean squared error of approximation.

Overall the results of this study indicate that the measurement part of the model was created successfully. While the data for the Conners' CPT do not appear to be normally distributed, all indices are important in their contribution to the latent construct of Attention.

The causal relationships among the six variables for the model were examined by the following set of equations:

$$X_1 = R_1 \quad (1)$$

$$X_2 = P_{21}X_1 + R_2 \quad (2)$$

$$X_3 = P_{31}X_1 + P_{32}X_2 + R_3 \quad (3)$$

$$X_4 = P_{41}X_1 + P_{42}X_2 + P_{43}X_3 + R_4 \quad (4)$$

$$X_5 = P_{51}X_1 + P_{52}X_2 + P_{53}X_3 + P_{54}X_4 + R_5 \quad (5)$$

$$X_6 = P_{61}X_1 + P_{62}X_2 + P_{63}X_3 + P_{64}X_4 + P_{65}X_5 + R_6 \quad (6)$$

Table 6 presents the unstandardized maximum likelihood estimates of the structural paths. The unstandardized maximum likelihood estimates of all paths are presented in Appendix A. In examining the equations for the direct and indirect influences of variables within the model, findings indicated that, as expected, the cognitive pathway in the model is significant for predicting academic achievement deficits in long-term survivors of childhood cancer, but contrary to the hypothesized model, the attentional pathway is significant for predicting academic achievement deficits only as mediated by classroom performance.

Table 6

AMOS Maximum Likelihood Estimates for Structural Paths

Path		Regression weights		
		Estimate	SE	CR
ADHD/Inattentive <---------------	AGETEST	-.065	.013	-5.156***
ADHD/Inattentive <---------------	Gender	-.250	.079	-3.158***
Intelligence <----------------------	AGETX	1.497	.381	3.929***
Intelligence <----------------------	TXINT	-7.725	1.950	-3.961***
Intelligence <----------------------	MOSOFF	.033	.031	1.060^{NS}
Intelligence <----------------------	Education	11.143	1.579	7.059***
Attention <--------------------------	ADHD/Inattention	-1.195	1.841	-.647^{NS}
Classroom Perf. <----------------	ADHD/Inattention	.689	.072	9.565***
Classroom Perf. <----------------	Intelligence	-.017	.003	-5.789***
Academic Ach. <------------------	Attention	.025	.024	1.049^{NS}
Academic Ach. <------------------	ADHD/Inattention	2.351	1.136	2.069*
Academic Ach. <------------------	Classroom Perf.	-5.354	1.425	-3.756***
Academic Ach. <------------------	Intelligence	.629	.075	8.342***
ADHD/Inattentive <---------------	Intelligence	-.017	.004	-3.955***
Intelligence <----------------------	ADHD/Inattentive	3.046	2.660	1.145^{NS}

Note. ADHD/Inattentive = The latent variable for observed inattention; Intelligence = The latent variable for IQ; Attention = The latent variable for measured attention; Classroom Perf. = The latent variable for observed classroom performance; Academic Ach. = The latent variable for academic achievement; AGETEST = The observed variable for age at testing; Gender = The observed variable for gender; AGETX = The observed variable for age at treatment; TXINT = The observed variable for treatment intensity; MOSOFF = The observed variable for months off treatment; Education = The latent variable for family education.

^{NS} - not significant

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

Figure 4 presents the results for the final analysis of the hypothesized model. In the overall final model a significant amount of the variance (R^2 = .847) was explained by the set of independent variables in the model for contributors to academic achievement deficits. The squared multiple correlations are presented in Appendix B. The results of the analysis for the model indicate that higher family education has a positive influence on higher intelligence with a path coefficient of .56. Age at treatment had a positive influence on intelligence, with a path coefficient of .29, indicating the older the child at treatment, the higher the

IQ scores. Treatment intensity has a negative influence on IQ, with a path coefficient of -.24, indicating the more intensive the treatment the child receives, the lower the IQ score. However the length of time since the child completed treatment does not have a significant influence on IQ scores, with a path coefficient of .07. Both age at testing and gender have a negative influence on ADHD/Inattentive Type, with path coefficients of -.30 and -.17 respectively. The findings suggest that younger children have more difficulty with inattention in class and boys are also more likely to have difficulty with inattention than girls.

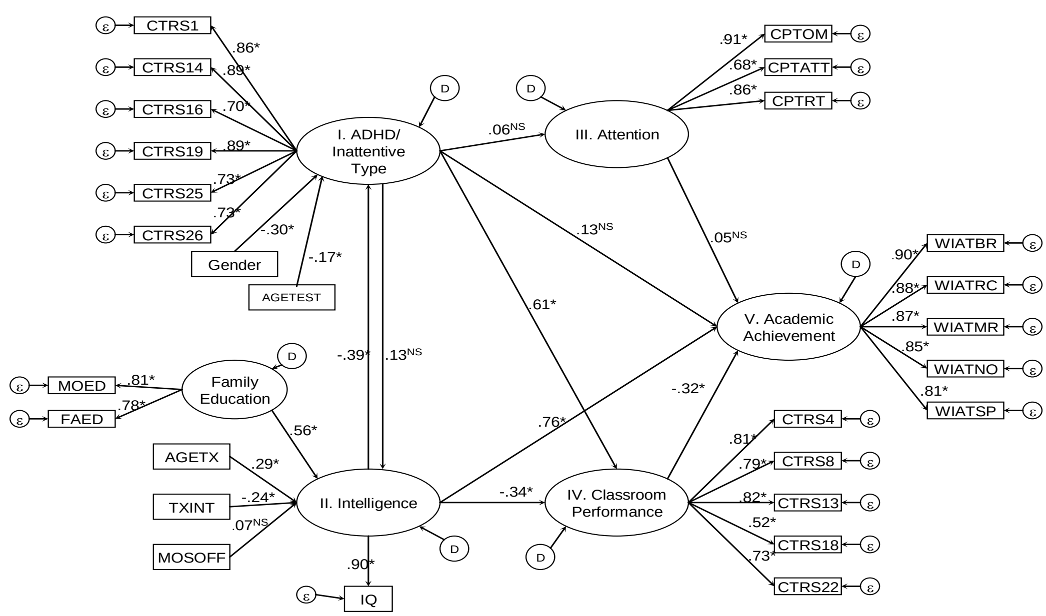

Figure 4. Final Model of Contributors to Academic Achievement Deficits in Childhood Cancer Survivors (standardized estimates). Note. AGETEST = Age at Testing; Gender = Gender; MOED = Mother's Education; FAED = Father's Education; AGETX = Age at Treatment; TXINT = Treatment Intensity; MOSOFF = Months off Treatment; IQ = WISC IQ; CTRS1 – CTRS26 = Questions from the Conners Teacher Rating Scale – Revised: Short Form; CPTOM = Conners CPT Omissions; CPTATT = Conners CPT Attentiveness; CPTRT = Conners CPT Risk Taking; WIATBR = WIAT Basic Reading; WIATRC = Wechsler Individual Achievement Test (WIAT) Reading Comprehension; WIATMR = WIAT Math Reasoning; WIATNO = WIAT Numerical Operations; WIATSP = WIAT Spelling
* $p < .05$

As expected, ADHD/Inattentive Type is directly predicted by Intelligence, with a path coefficient of -.40, but ADHD/Inattentive Type is not significant in predicting Intelligence, with a path coefficient of .13. Children with lower IQs within this model have more difficulty with inattentive behavior as observed by teachers. Classroom performance is directly predicted by intelligence, with a path coefficient of -.34. Lower IQ leads to more difficulty in classroom performance. Intelligence also has both a significant direct, with a path coefficient of .76, and indirect influence, as mediated by classroom performance and ADHD/Inattentive Type, on academic achievement deficits. Classroom performance has a direct negative influence, with a path coefficient of -.32, on academic achievement deficits. Lower IQ leads to greater academic achievement deficits in children who are long-term survivors of cancer. Additionally, lower IQ predicts more difficulty in classroom performance, which in turn, predicts greater academic achievement deficits. Finally, lower IQ predicts more difficulty with observed inattentive behavior, leading to more difficulty with classroom performance and consequently greater academic achievement deficits.

The hypothesis that observed inattention has direct effects on attention, as measured by objective testing, and academic achievement deficits in this model was not supported. The direct path between ADHD/Inattentive Type and Attention, with a path coefficient of .04, was not significant. The direct path between Attention and Academic Achievement, with a path coefficient of .04, was not significant, nor was the direct path between ADHD/Inattentive Type and Academic Achievement, with a path coefficient of .13, significant. Analysis further revealed that the indirect path between ADHD/Inattentive Type, as mediated by Attention, was not significant.

In examination of the total path predicting academic achievement deficits in children who are long-term survivors of cancer, it was found that both age at treatment and treatment intensity, as mediated through the pathway of intelligence, ADHD/Inattentive Type and classroom performance indirectly predicted academic achievement deficits. However, months off treatment did not have a significant indirect effect on academic achievement. All direct, indirect and total effects of the variables in the contributors to academic achievement deficits model are presented in Appendix C.

Chapter VII

Discussion

The purpose of this study was to examine the hypothesized model of contributors to academic achievement deficits in long-term survivors of childhood cancer. This model was derived from the most salient aspects of the research models of Reddick et al. (2003) and Rapport et al. (1999) that explored attention and cognitive deficits in the pediatric cancer and ADHD populations. The preponderance of previous research has indicated that both age at treatment and treatment intensity contribute to declines in IQ. The research results in the areas of attention late effects and academic achievement declines have been less compelling. The results of this study only partially support the hypothesized developmental model, stating that high intensity treatment that includes radiation therapy as all or part of the child's treatment for a brain tumor or acute lymphocytic leukemia at a young age results in academic achievement deficits. The present findings indicate that, while controlling for SES, age and gender, these treatment factors result in declines in IQ, lead to both declines in cognitive performance and more difficulty attending to task in the classroom, which, in turn mediate declines in academic achievement. Contrary to the findings of Reddick et al. (2003), attention, as observed by teachers and as measured in the laboratory, has no direct influence on academic achievement deficits in this sample.

Another finding that appears to be contrary to much of the existing research is that the length of time since treatment does not appear to significantly contribute to declines in IQ. Therefore, the length of time since treatment has no significant contribution to academic achievement declines in this sample. Many of the studies that suggest the length of time since treatment is important in the development of cognitive late effects in this population occurred more than ten years prior to the current study. Conklin and colleagues' (2008) study of academic and IQ declines in children treated with more conservative cranial radiation therapy for a brain tumor suggests no significant declines in IQ over time. Treatment regimes have changed in recent years in an effort to preserve cognitive functioning while still providing effective amelioration of the cancer. The results of the present study may be a reflection of these improvements in treatment.

The results of this analysis do not support the importance of attention, as measured in the lab, as a significant predictor, either through direct effect, or as a mediator in the path of the influence of treatment variables on academic achievement. Even when the three Conners' CPT indices were omitted from the final analysis due to low reliabilities, attention was not a significant contributor to the model. There are several possible explanations for this finding. First, inspection of the data for distribution indicated problems with a leptokurtic distribution in five of the six Conners' CPT indices that were used to comprise the latent variable for attention. Thus there is a potential violation of the assumption that the sample distribution for this particular measure is representative of the population of long-term survivors of childhood cancer. Second, the Conners' CPT may not possess the specificity or sensitivity to adequately measure important attentional contributors to academic achievement deficits in this population. Further exploration of the validity of the Conners' CPT revealed a study of the estimates of the validity of the Conners' CPT in the assessment of inattentive behavior (Edwards et al., 2007). Findings of this study indicated no significant, positive correlations between the Conners' CPT and teacher ratings of inattentive behavior. This lack of correlation between the Conners' CPT and teacher ratings may be evident with the population of long-term survivors of childhood cancer as well. Third, the Conners' CPT is an objective measure of sustained attention that is conducted in a lab with minimal distractions. The CTRS-R:S is an ecological measure of observed behavior and as such, is more subjective in the results it yields. Standardized clinical measures are important in the diagnostic process, but do not fully assess the behavioral problems the child is experiencing in the classroom that may lead to academic achievement deficits. (Achenbach & Edelbrock, 1978).

Rapport and colleagues (1999) suggested that teacher-observed ADHD-related behavior problems may interfere with academic achievement by virtue of their impact on classroom performance to a greater degree than associated cognitive abilities as measured in the lab. The present model supports this finding in this sample. The latent variable Classroom Performance in the model was significant in its direct influence and the latent variable of ADHD/Inattention was significant in its indirect influence on academic achievement deficits in pediatric cancer survivors. The model is also consistent with research findings that lower IQ scores among pediatric brain tumor or ALL survivors are related to their difficulties with keeping up with their peers in their acquisition of new learning (Palmer et al., 2001). Reddick and colleagues (2003) demonstrated a pathway by which treatment for a brain tumor created changes in the brain that resulted in academic achievement deficits. These changes were mediated by declines in IQ and attention. The findings of the present study support this pathway of academic achievement deficits, but differ in the nature of the mediating variables that influence the deficits. The influence of attention, as measured by the Conners' CPT in the model by Reddick and colleagues (2003) is not significant in the present model. However, behavioral observations of inattention in the classroom are important in predicting academic achievement deficits. It may be that the ecological nature of the observations is more accurate in assessing the difficulties pediatric brain tumor or ALL survivors have with keeping up with their peers in their acquisition of new learning.

Overall, the developmental model for academic achievement deficits adds to the previous research in the area of late effects of treatment for childhood cancer by combining variables to arrive at a more complete explanation of the changes seen in academic achievement in pediatric cancer survivors. There is empirical support for the construct validity of the factor structure of the CTRS-R:S with a sample of survivors of childhood cancer who received central nervous system treatment (Helton et al., 2006).

Limitations

Several limitations of this study should be noted, including a potentially limiting sample size. Although the use of samples of greater than 200 is supported in the literature (Aleamoni, 1976; Loo, 1983; MacCallum, Widaman, Preacher, & Hong, 2001), Jackson (2001) found an increase in sample size from 50 to 400 yielded a 29% improvement in the fit indices. However an additional increase of 400 for a sample size of 800 yielded only an additional 2.5% improvement in the fit indices. Bollen (1990) showed that sample size does not affect the calculation of NFI, but argued that due to the lack of consensus of the importance of sample size it is prudent to report multiple measures. The sample size of 302 is below the lower-bound requirement of 550, as suggested by Jackson (2001), indicating that the results may be affected by low statistical power. Given these concerns, a larger sample may have yielded results that supported the full hypothesized model rather than part of the model.

Another limitation is the generalizability of the results to other settings that serve pediatric survivors of cancer. While the study from which the data was derived was a multi-site study, the participants in this study were patients at a single pediatric cancer research center where specific treatment protocols and follow-up are prescribed for specific disease processes. Most other centers are considered treatment facilities where a wide variety of treatment options are available to patients. While the participants were from a variety of socioeconomic backgrounds and geographical locations, the sample was limited to children treated for a brain tumor or ALL. Therefore, these results may not generalize to other children who are treated for cancer who receive central nervous-system directed treatment.

The squared multiple correlations may be over inflated due possible shared method variance and a high correlation between some of the variables, therefore the results should be interpreted with caution. First, because the data for two of the latent variables (i.e., ADHD/Inattentive and Classroom Performance) were from the CTRS-R:S, there may be a problem with shared method variance due to high correlation between the variables. Bank and colleagues (1990) noted that if one defines independent variables with common measures (e.g., observer impressions) in a structural model, the estimated effect coefficients could be much higher than when the variables are defined by non-overlapping indicators. Examination of the correlations between these two latent variables yielded a moderate correlation (r = .687). Second, the correlation between the latent variables Achievement and Intelligence is relatively high (r = .789). Studies have consistently shown moderate to high correlations between achievement and intelligence. Pearson product-moment correlations coefficients of achievement with IQ for four of these studies in the past 30 years have ranged from .37 to .82 (Foley, Garcia, Shaw, & Golden, 2009; Gettinger & White, 1979; Naglieri, De Lauder, Goldstein, & Schwebech, 2006; Naglieri & Rojahn, 2004). Cognitive ability and academic achievement share a significant portion of the same construct, therefore tests of cognitive ability should correlate with tests of academic achievement (Naglieri & Rojahn, 2004). The assumption is that whatever the IQ test measures is important academic performance outcomes.

Summary and Recommendations

In summary, the results from the developmental model clearly indicate that treatment factors are significant in their influence on academic achievement outcomes in long-term survivors of childhood cancer. Due to the lack of significant contribution of the clinical measures of attention in this model, the results suggest that long-term survivors of childhood cancer likely exhibit behavioral symptoms of inattention that differ quantitatively from those of other children diagnosed with the inattentive type of ADHD.

Results from the present study indicate the Conners' Teacher Rating Scale – Revised: Short Form is effective in identifying attentional problems in long-term survivors of childhood cancer. Consideration should be made to include this instrument in the assessment battery a practitioner chooses to use in evaluating the nature and degree of attentional problems in the child being assessed. Furthermore, results from this study suggest the need to evaluate the utility of the Conners' CPT in the assessment of late effects in this population. This evaluation may include more accurate conceptualization of how attentional dysfunction in long-term survivors of childhood cancer differs from those characteristics previously attributed to this population and exploration of optimal clinical measures to use in assessments.

Finally, further exploration of the nature of academic achievement deficits and the degree of contribution of attentional problems in this population would lead to greater understanding of how these issues contribute to the overall success of long-term survivors of childhood cancer in school. Exploration of other contributing factors within the context of a similar structural equation model, such as the impact of reduced white-matter volume as explored by Reddick and colleagues (2003) would contribute to understanding the nature of these deficits more definitively and, subsequently, interventions to prevent damage or remediation strategies for children with identified deficits.

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Appendix A

Unstandardized Maximum Likelihood Estimates of All Paths and Variances

Path		Regression weights		
		Estimate	SE	CR
ADHD/Inattentive <---------------	AGETEST	-.065	.013	-5.1616***
ADHD/Inattentive <---------------	Gender	-.250	.079	-3.158***
Intelligence <-----------------------	AGETX	1.497	.381	3.929***
Intelligence <-----------------------	TXINT	-7.725	1.950	-3.961***
Intelligence <-----------------------	MOSOFF	.033	.031	1.060^{NS}
Intelligence <-----------------------	Education	11.143	1.579	7.059***
Attention <---------------------------	ADHD/Inattention	-1.195	1.841	$-.649^{NS}$
Classroom Perf. <-----------------	ADHD/Inattention	.689	.072	9.565***
Classroom Perf. <-----------------	Intelligence	-.017	.003	-5.789***
Academic Ach. <-------------------	Attention	.025	.024	1.049^{NS}
Academic Ach. <-------------------	ADHD/Inattention	2.351	1.136	2.069*
Academic Ach. <-------------------	Classroom Perf.	-5.354	1.425	-3.756***
Academic Ach. <-------------------	Intelligence	.629	.075	8.342***
ADHD/Inattentive <---------------	Intelligence	-.017	.004	-3.955***
Intelligence <-----------------------	ADHD/Inattentive	3.046	2.660	1.145^{NS}
CTRS Item 26 <--------------------	ADHD/Inattentive	1.000		
CTRS Item 25 <--------------------	ADHD/Inattentive	.992	.079	12.626***
CTRS Item 19 <--------------------	ADHD/Inattentive	1.305	.084	15.597***
CTRS Item 16 <--------------------	ADHD/Inattentive	.884	.074	11.988***
CTRS Item 14 <--------------------	ADHD/Inattentive	1.241	.080	15.486***
CTRS Item 1 <---------------------	ADHD/Inattentive	1.209	.080	15.061***
CPT Omissions <------------------	Attention	1.000		
CPT Attentiveness <--------------	Attention	.363	.030	12.135***
CPT Risk Taking <----------------	Attention	.820	.061	13.431***
WIAT Basic Reading <-----------	Academic Ach.	1.000		
WIAT Reading Comp. <---------	Academic Ach.	1.050	.046	22.980***
WIAT Spelling <--------------------	Academic Ach.	1.034	.047	22.125***
WIAT Math Reasoning <--------	Academic Ach.	1.046	.049	21.169***
WIAT Numeric Op. <-------------	Academic Ach.	1.003	.052	19.346***
CTRS Item 4 <---------------------	Classroom Perf.	1.000		
CTRS Item 8 <---------------------	Classroom Perf.	1.013	.068	14.926***
CTRS Item 13 <--------------------	Classroom Perf.	1.216	.078	15.562***
CTRS Item 18 <--------------------	Classroom Perf.	.537	.059	9.113***
CTRS Item 22 <--------------------	Classroom Perf.	1.028	.076	13.554***
Mother's Ed. <----------------------	Family Education	1.000		
Father's Ed. <----------------------	Family Education	1.106	.133	8.299***
IQ <----------------------------------	Intelligence	1.000		

Variances	Estimate	S.E.	C.R.
AGETEST	11.173	.911	12.268***
Gender	.247	.020	12.268***
AGETX	10.440	.851	12.268***
TXINT	.249	.020	12.268***
MOSOFF	1346.3	109.7	12.268***
Res1	.405	.059	6.922***
Res2	186.52	32.23	5.787***
Res3	426.73	51.88	8.226***
Res4	27.713	8.780	3.156**
Res5	.243	.037	6.642***
Res6	.680	.112	6.075***
Error1	.262	.027	9.779***
Error2	.220	.024	9.136***
Error3	.436	.038	11.482***
Error4	.228	.026	8.922***
Error5	.449	.040	11.306***
Error6	.458	.041	11.310***
Error7	.449	.097	4.621***
Error8	.447	.082	5.440***
Error9	64.702	20.292	3.189**
Error10	153.05	27.77	5.511***
Error12	58.678	5.792	10.123***
Error13	132.60	19.870	6.673***
Error16	43.216	4.640	9.315***
Error17	57.708	5.869	9.832***
Error18	64.499	6.349	10.159***
Error19	76.994	7.358	10.464***
Error20	94.141	8.622	10.918***
Error21	.358	.037	9.682***
Error22	.411	.041	9.962***
Error23	.492	.052	9.484***
Error24	.509	.043	11.754***
Error25	.609	.057	10.675***

Note. Error terms for error 11, error 14 and error 15 omitted from final model when Conners CPT variables for Hit Reaction Time, Block Change and Interstimulus Interval Change omitted. ADHD/Inattentive = The latent variable for observed inattention; Intelligence = The latent variable for IQ; Attention = The latent variable for measured attention; Classroom Perf. = The latent variable for observed classroom performance; Academic Ach. = The latent variable for academic achievement; AGETEST = The observed variable for age at testing; Gender = The observed variable for gender; AGETX = The observed variable for age at treatment; TXINT = The observed variable for treatment intensity; MOSOFF = The observed variable for months off treatment; Education = The latent variable for family education.

^{NS} - not significant ; * $p < .05$; ** $p <.01$; *** $p <.001$

Appendix B

Squared Multiple Correlations

Variable	Estimate
Family Education	.000
!. ADHD/Inattentive Type	.225
II. Intelligence	.307
III. Attention	.002
IV. Classroom Performance	.634
V. Academic Achievement	.847
Father's Ed.	.649
Mother's Ed.	.603
IQ	.806
CTRS Item 1	.745
CTRS Item 4	.649
CTRS Item 8	.624
CTRS Item 13	.666
CTRS Item 14	.785
CTRS Item 16	.484
CTRS Item 18	.273
CTRS Item 19	.796
CTRS Item 22	.535
CTRS Item 25	.534
CTRS Item 26	.533
CPT Risk Taking	.745
CPT Attentiveness	.459
CPT Omissions	.830
WIAT Reading Comprehension	.778
WIAT Basic Reading	.810
WIAT Numerical Operations	.663
WIAT Math Reasoning	.723
WIAT Spelling	.753

Appendix C

Direct, Indirect and Total Effects of Latent Variables with the Model

Variable	Direct Effects	Indirect Effects	Total
		Intelligence	
Family Education	11.14** (.560)	0	11.14*** (.560)
ADHD/Inattentive Type	3.046 (.134)	0	3.046 (.134)
		ADHD/Inattentive Type	
Family Education	0	-.185** (-.211)	-.185** (-.211)
Intelligence	-0.17** (-.396)	0	-0.17** (-.396)
		Attention	
Family Education	0	.221 (.009)	.221 (.009)
Intelligence	0	.020 (.016)	.020 (.016)
ADHD/Inattentive Type	-1.195 (-.042)	0	-1.195 (-.042)
		Classroom Performance	
Family Education	0	-.308*** (-.312)	-.308*** (-.312)
Intelligence	-.017*** (-.344)	-.011*** (-.213)	-.028*** (-.557)
ADHD/Inattentive Type	.689** (.612)	0	.689*** (.612)
		Academic Achievement	
Family Education	0	7.896*** (.479)	7.896*** (.479)
Intelligence	.629** (.761)	.078* (.094)	.707*** (.855)
ADHD/Inattentive Type	2.351* (.125)	-1.566* (-.084)	.785* (.041)
Attention	.025 (.038)	0	.025 (.038)
Classroom Performance	-5.354* (-.322)	0	-5.354* (-.322)

Note: Metric coefficients are given in parentheses.
* p < .05
** p < .01
*** p < .001