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Attentional processes and their remediation in children treated for cancer: A literature review and the development of a therapeutic approach

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Abstract

It is now generally accepted that central nervous system treatments for childhood cancer can result in significant cognitive impairment, most commonly in the areas of attention/concentration. We review the literature on attentional and neurocognitive deficits in this population, and also efforts to remediate attentional deficits in other brain injured populations. It was our goal to develop an innovative, psychologically based outpatient rehabilitation program that would improve dysfunctional attentional processes and associated neuropsychological deficits. The characteristics of this program and a pilot study of its effectiveness are described. Participants were 31 off-therapy cancer survivors with documented attention deficits. Twenty-one completed the cognitive remediation program (CRP) and 10 served as comparisons. All participants completed a test of vigilance attention, 2 tests with an attentional component, and an arithmetic academic achievement measure. When the scores of the 2 groups were compared, the CRP group exhibited statistically significant improvement on all attentional measures. In contrast, the comparison group did not manifest any significant changes. Neither group demonstrated statistically significant changes on the arithmetic achievement test. We believe that the CRP has potential for improving attention/concentration, but generalization to academic achievement remains unproven. Phase 3 clinical trials and the documentation of long-term treatment gains are needed. Furthermore, it will be necessary to demonstrate the ecological validity of the CRP. With these caveats, this therapeutic approach may be helpful in other populations of cognitively impaired children and young adults, such as patients who have suffered traumatic brain injury. (*JINS*, 2002, *8*, 115–124.)

Keywords: Rehabilitation, Pediatric cancer survivors, Attention deficits

INTRODUCTION

The incidence of the two most common childhood cancers (leukemia and brain tumors) is increasing, even though mortality from these illnesses is decreasing (Ries et al., 1999). In fact, the occurrence of neural solid tumors in U.S. children now exceeds acute lymphocytic leukemia (Bleyer et al., 1997). Curative treatment for the leukemias and lymphomas has been attained in large part by the introduction of central nervous system (CNS) prophylactic treatments (Magrath, 1989; Poplack, 1989). Prophylaxis involves cranial irradiation (CRT) and/or intrathecal injection of chemotherapies. The goal is the elimination of cancerous cells in the CNS in order to prevent eventual disease spread and relapse. Additionally, cranial irradiation is part of the direct treatment for many brain tumors and some high risk leukemias (Heideman et al., 1989; Pizzo & Poplack, 1997). Unfortunately, these life-saving treatments can be detrimental to quality of life, particularly in the school environment because of their adverse effects on attention and concentration, and other neurocognitive functions (Brouwers et al., 1984; Buono et al., 1998; Butler et al., 1994; Copeland et al., 1988; Lockwood et al., 1999; Moore et al., 1992; Ochs et al., 1991; Packer, 1989; Ris & Noll, 1994).

Although neurons have a relatively high tolerance to irradiation and appear to survive at doses up to approximately 6500 cGy (Bouchard, 1966), these doses are very

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destructive to other CNS tissues (Sheline et al.,1980). Many patients treated for brain tumors suffer rather severe deficits in attention/concentration, intelligence, motor abilities, memory, and academic skills (Butler et al., 1994; Moore et al., 1992; Packer et al., 1989; Radcliffe et al., 1994; Ris & Noll, 1994; Riva et al., 1989; Silber et al., 1992). These deficits can be progressive in nature (Hoppe-Hirsch et al., 1990). As survivors enter adulthood, unemployment becomes extremely common (Mostow et al., 1991), probably because of poor academic achievement secondary to attentional and neurocognitive deficits. Current treatment protocols for most childhood brain tumors continue to be associated with significant neurocognitive impairment which includes not only attentional deficits, but also executive dysfunction, declines in verbal intelligence and memory problems (Copeland et al., 1999). These findings are complicated, however, by evidence that nontreatment related tumor factors, though often slight, can also impinge on a child's neuropsychological status (Brookshire et al., 1990). Pediatric brain tumor survivors who received CRT have been shown to have significantly less volume of CNS white matter, and corresponding deficits in measured intelligence (Mulhern et al., 1999). This is particularly relevant to the current discussion because white matter disease has been strongly associated with deficits in sustained attention and concentration (Rao, 1996). Even with this confirmatory evidence, cautions must be raised regarding the association between CRT and attentional disturbances. Task complexity and attention are interrelated. Given that children treated for many, but not all brain tumors clearly tend to experience greater overall cognitive decline, some deficits may be due to difficulty in the comprehension of task demands rather than attentional impairment *per se*.

The dosage of CRT that is used as a CNS prophylactic treatment with the leukemias and lymphomas is much lower than that used to treat CNS tumors. Nevertheless, neuropsychological studies have confirmed that these lower doses of CRT can still result in significant cognitive impairment, most commonly a disturbance in attention/concentration, nondominant hemisphere dysfunction, declines in nonverbal intelligence, and difficulties in arithmetic skills (Brouwers et al., 1984; Brouwers & Poplack, 1990; Butler, 1994; Fletcher & Copeland, 1988; Jankovic et al., 1994; Moore et al., 1992; Ochs et al., 1991). Further research has confirmed the relationship between CNS treatments and attentional disturbances in children off treatment (Hertzberg et al., 1997; Lockwood et al., 1999). It should be noted that older studies on leukemia CNS therapy were conducted when a higher dose (2400 cGy) of CRT was administered. Unfortunately, the currently used dose of CRT (1800 cGy) has been reported to result in similar, although possibly less severe neuropsychological impairment (Anderson et al., 2000; Raymond-Speden et al., 2000). While there are studies that have failed to report neurocognitive involvement following CRT (Ivnik et al., 1981; Ochs et al., 1986), they are older and have been criticized on methodological grounds (Butler & Copeland, 1993).

The exact nature of the attentional deficits induced by CRT remains poorly understood. Given that irradiation to the brain is known to cause demyelination and white matter disease (Burger & Boyko, 1991), impaired neural transmission with reduced information processing efficacy is one likely cause for these deficits. There is preliminary evidence that vigilance attentional processes are particularly susceptible to disruption in this population (Butler et al., 1999). Further research is clearly needed so that the relationship between attention and other neuropsychological processes, such as working memory and information processing, can be delineated in this population. The effects of chemotherapy alone on cognition and behavior have received less attention than CRT as a CNS treatment or prophylaxis. The few studies that have been published, however, suggest the possibility of associated attentional and other neuropsychological deficits following the use of methotrexate (Bleyer & Griffin, 1980; Brown et al., 1996; Hill et al., 1997; Meadows & Evans, 1976; Ochs et al., 1991; Raymond-Speden et al., 2000). These impairments, however, appear to be less frequent and severe than those reported following CRT (Brown et al., 1998; Butler et al., 1994; Copeland et al., 1996).

In light of the large amount of effort that has been accomplished in documenting neuropsychological deficits secondary to childhood cancer treatments, surprisingly little work has been directed towards the rehabilitation of these deficits. In an exhaustive literature search, we were able to locate only one study on cognitive remediation in survivors of childhood cancer who had received treatment to the CNS or suffered a CNS cancer (Butler, 1998). There does, however, exist a body of research on cognitive remediation of attentional deficits with head-injured adults and children. Cognitive remediation, rehabilitation, and retraining are all terms that refer to systematic therapeutic efforts designed to improve cognitive functioning after a CNS insult (Butler & Namerow, 1988). Historically, a key component in cognitive rehabilitation has been repeated practice on cognitive tasks in order to restore neuropsychological function. The theoretical basis for this approach can be traced to the work of the Russian neurologist Alexandr Luria (1963). He posited that the brain is not a static system, and that functional reorganization of neural pathways can occur after a CNS insult. Research investigating the effects of cognitive remediation on attention/concentration deficits has been generally supportive. Ten published studies have reported beneficial effects from cognitive retraining for attention deficits (Ben-Yishay et al., 1980; Gray & Robertson, 1989; Kewman et al., 1985; Niemann et al., 1990; Ponsford & Kinsells, 1988; Sohlberg et al., 2000; Sohlberg & Mateer, 1987; Strache, 1987; Sturm et al., 1997; Wilson & Robertson, 1992).

The above findings have important implications for pediatric cancer survivors. There is now widespread acceptance that many of these children from the three most common diagnostic categories suffer impaired attentional skills and other neurocognitive deficits following completion of treatment. These and other neuropsychological deficits have an adverse effect on academic achievement (Haupt et al., 1994; Madan-Swain & Brown, 1991; Mulhern et al., 1992), thereby compromising quality of life. If an effective remediation program could be developed and implemented with this population, it would lessen one of the major late effects of childhood cancer treatment. The above reported studies on improved attentional functioning following cognitive remediation have used traditional brain damage rehabilitation techniques. These methods involve having the individual engage in challenging tasks and exercises that are thought to stimulate brain function (Sohlberg & Mateer, 1989). The model is very similar to the treatment approach used by a physical therapist. Although this approach is generally effective in improving the individual's performance on tasks similar to the training exercises, limited generalization to dissimilar tasks and everyday life functioning has been the rule. This is a critical problem in neurocognitive rehabilitation because the process is time consuming and costly. This state of affairs prompted Butler and Namerow (1988) to advocate for a skill acquisition model of cognitive remediation. This approach deemphasizes task practice and involves teaching the patient strategies that will enable him/her to maximize their own resources and effectively monitor their performance. Direct attention to real word functioning is given primary importance. The timeliness of this model has recently been documented, and there is a growing consensus for moving beyond the traditional drill oriented model of cognitive remediation (Mateer et al., 1996; Wilson, 1997).

In summary, long-term survival of many childhood cancers has become a reality over the past several decades. Some of the treatments for these cancers or the disease itself can result in significant impairment in attention/concentration abilities and information processing efficacy, and other neuropsychological deficits. These cognitive problems negatively affect academic achievement, particularly in arithmetic. Considerable work has been accomplished to establish the above facts; however, there have been no programmatic efforts designed to remediate neuropsychological and academic dysfunction in these children, adolescents and young adults. An eminent neuropsychologist recently wrote, "We have, in fact, become quite sophisticated in the assessment of brain-disordered patients, but the development of effective programs of neuropsychological treatment remains one of the most pressing needs and awesome challenges" (Brandt, 1997, p. 486). Attentional processes are served by numerous structures in the brain, and it is possible that a program of cognitive remediation directed towards pediatric cancer survivors might lessen impairments in these processes. For this type of program to be maximally effective it would need to have a skills acquisition model and address all aspects of attentional processes, and be sensitive to the variability in the severity of neuropsychological deficits in this population. The current article describes a cognitive remediation program (CRP) that incorporates a tripartite skills acquisition approach. A published case report has documented the potential effectiveness of this modified approach (Butler, 1998). In this paper we will present pilot data that are supportive of our ability to improve attentional skills in childhood cancer survivors who have received treatments likely to affect the CNS, and/or who have suffered a CNS cancer.

METHODS

Cognitive Remediation Program

The cognitive remediation program combines methods and techniques used by three disciplines: (1) brain injury rehabilitation, (2) special education/educational psychology and, (3) clinical psychology. From the brain injury rehabilitation field, the Attention Process Training (APT) cognitive rehabilitation program developed by Sohlberg & Mateer (1986) is administered to all patients. This program consists of a series of hierarchically graded attentional exercises that stimulate multidimensional aspects of attention and concentration. Specifically, activities are designed to strengthen attentional skills and information processing speed in the areas of sustained attention, selective attention, divided attention, and executive attentional control. Selection of specific exercises is guided by a 50–80% rule. If the participant is unable to complete at least 50% of the activity correctly, the task is considered too complex and a more basic activity is selected. When 80% accuracy is obtained, the next level of complexity is instituted. In order to make the therapeutic approach more attractive to children and adolescents, we added a number of games and colorful activities to the APT program in order to stimulate interest. These activities include computer administered solitare software, card games and memory matching games. Several manuals describing the CRP approach in greater detail, including a listing of all the individual activities, are available from the first author on request.

From the education field we assembled a dictionary of approximately 15 metacognitive strategies. These strategies were designed to address the following general areas: (1) preparedness, (2) task approach, (3) on-task behavior, and (4) generalization. As an example of a preparedness strategy, patients are taught a brief breathing exercise and also assisted in identifying a special word or term which signals their readiness to begin a difficult task. Task approach strategies included learning a systematic manner in which to complete activities and giving oneself appropriate encouragement. On-task strategies also involve maintaining an encouraging self-dialogue over the course of an exercise, and repeatedly checking one's own work. In order to promote generalization, parents and teachers are supplied with lists of the child's strategies and encouraged to ensure that these are used both at home and in school. The Appendix lists 15 examples of metacognitive strategies that were taught to participants.

From the clinical psychology literature, cognitive-behavioral interventions (Kendall, 1991) are used with each child. These are designed to improve resistance to distraction, and also to help the child learn how to be his/her own coach over the course of a long and difficult activity. Cognitive–behavioral interventions involve modeling an appropriate internal dialogue in an overt fashion. Then the child practices this dialogue, again in an overt manner. Finally, once the child has demonstrated acquisition of appropriate skills, he/she then uses the dialogue in a covert fashion. The therapist serves as an active distractor once the child has acquired the cognitive skills. Within the cognitive–behavioral framework, the child is also taught to use mnemonic strategies such as visual imagery and chunking (Sohlberg & Mateer, 1989).

The cognitive remediation program consisted of approximately 50 hours of treatment over the course of 6 months. Children and adolescents were seen 1 time per week for a 2-hr period, with a 15-min break separating the 2 treatment hours. The number of treatment sessions was selected based on rehabilitation standard of care. This decision was guided by a desire to balance maximal intervention effectiveness with a moderate length of treatment involvement. Each child had an individual therapist who also interacted with the child's parent and, whenever possible, the child's teacher. If we were not able to contact the teacher, the parent was requested to provide the teacher with a list of the patient's strategies. While programmatic, the cognitive remediation program also has an individualized component. Each child manifests his/her own strengths and weaknesses, and treatment is individualized accordingly. We believe there is likely to be a nonspecific psychotherapeutic component to the program. As noted above, each child has his or her own therapist who clearly wants the patient to succeed. We suspect that this supportive environment also benefits the individual's functioning, and most likely stimulates a strong motivational drive.

Research Participants

Twenty-one cancer survivors have now completed the CRP. Ten were diagnosed with a brain tumor, 9 with a leukemia or lymphoma, and 2 with osteosarcoma who had received high dose systemic methotrexate. Of the brain tumor participants who received the CRP, 3 were treated for medulloblastoma, 3 for astrocytoma, 1 for craniopharyngioma, 1 for multifocal granuloma, 1 for rhabdomyosarcoma, and 1 for a mixed germ cell tumor. The comparison group comprised children from these same diagnostic categories who were either on a waiting list to receive the CRP, or unable to attend training sessions because their residence was too distant from the cancer center. Of the 6 participants treated for a brain tumor that were in the comparison group, 3 had an astrocytoma, 1 a medulloblastoma, 1 a craniopharyngioma and 1 had a rhabdomyosarcoma. Although there is some degree of variability in tumor type within and between groups, they are roughly comparable. Brain tumor location and treatment history are summarized in Table 1.

The criterion for study inclusion was an attentional deficit following a treatment and/or cancer that was CNS related. The sample sizes are uneven because most families wanted their child to receive the CRP, even if it was difficult to attend scheduled appointments at the medical center. One participant in the CRP group was an adult (age 22) but had undergone cancer treatment prior to age 18. All other participants were below the age of 18 and none were younger than 6 years of age. Of all subjects originally enrolled in the CRP, 4 terminated prematurely and were not available for follow-up assessment (16% attrition rate). None of the comparison survivors were lost to attrition. Additional demographic and treatment-related data are presented in Table 2.

All subjects were fluent in English and manifested an attentional disturbance as documented by an overall index score greater than 0.00 on the Conners Continuous Performance Test (CPT; Conners, 1992). Participants were recruited at both of the authors' institutions, and individuals were excluded if they had a Full Scale Intelligence Quotient below 50, or if they had sensory and/or motor deficits that impaired their ability to comprehend and respond to tests and remediation materials/activities. One treatment participant was taking stimulant medication for an attentional disturbance. Nevertheless, he still manifested an attentional disturbance as defined above. There were no alterations in his medication regime over the course of his participation in the current study.

Measures

The Conners CPT (Conners, 1992) is a test of sustained vigilance and attention. Subjects are required to press a key when a letter appears on a computer screen unless it is the letter *X*, in which case no response is to be made. The procedure lasts for approximately 14 min. Stimuli are presented in blocks of trials that have interstimulus intervals (ISI) of 1, 2, and 4 s. The order of the ISI varies between blocks. The test is computer administered and scored. The CPT generates the following indices of attention/concentration: (1) *Hits (correct responses)*; (2) *Omissions*; (3) *Commissions*; (4) *Hit Reaction Time (RT)*; (5) *Hit Reaction Time Standard Error*; (6) *Variability* (*SE*); (7) *Attentiveness* (d); and *Risk Taking* (β). A combination of these variables is entered into a linear multiple regression equation in order to obtain an overall index score (OIS) which has a range of 0.00 to 20.74. Any value above 4.00 is typically considered reflective of a significant attentional disturbance (Conners, 1992). To minimize familywise error rates, only the overall index score was used as a dependent variable.

Two additional measures that are influenced by attention and information processing were obtained. The Digit Span test from the Wechsler Intelligence Scale for Children–Third Edition (Wechsler, 1991) was administered in the standard manner. This is a test that combines auditory attention with working memory. Subjects also completed the

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Table 1. Brain tumor location and treatment history

Group	Location	Resection	Irradiation Dose
Cognitive remediation (CRP; $n = 10$)			
Multifocal Granuloma	Suprasellar	No	2,000 cGy whole brain
Medulloblastoma	—	Yes	3,500 cGy whole brain 1,500 cGy boost
Medulloblastoma	—	Yes	3,000 cGy whole brain 2,500 cGy boost
Medulloblastoma	—	Yes	3,000 cGy whole brain 2,500 cGy boost
Rhabdomyosarcoma	Suprasellar	Yes	3,000 cGy whole brain 2,000 cGy boost
Mixed Germ Cell	Suprasellar	Yes	3,600 cGy whole brain 1,800 cGy boost
Craniopharyngioma	—	Yes	5,400 cGy
Astrocytoma	Cerebellar	Yes	None
Astrocytoma	Suprasellar	Yes	5,100 cGy
Astrocytoma	Cerebellar	Yes	None
Comparison subjects (CS; $n = 6$)			
Craniopharyngioma	—	Yes	5,400 cGy
Medulloblastoma	—	Yes	3,000 cGy whole brain 2,400 cGy boost
Neuroepithelial	Suprasellar	Yes	None
Rhabdomyosarcoma	Suprasellar	Yes	3,000 cGy whole brain 2,000 cGy boost
Astrocytoma	Posterior fossa	Yes	5,400 cGy
Astrocytoma	Cerebellar	Yes	None

Sentence Memory subtest of the Wide Range Assessment of Memory and Learning (Sheslow & Adams, 1990). This test of sustained auditory processing uses verbal material for stimuli as opposed to the numeric content of Digit Span. Finally, the arithmetic section of the Wide Range Achievement Test–Third Revision (Wilkinson, 1993) was administered. This measure was obtained as an index of the degree to which CRP treatment benefits may have generalized to school related activities. All of the above variables were selected because they were reasonably divergent from the training stimuli used in the CRP activities.

RESULTS

There were no statistically significant differences between the groups in gender composition, age, years off treatment, or mean dosage of cranial irradiation. Descriptive and treatment outcome measures for the two groups are presented in Table 2. The data in Table 2 show that at pretreatment testing (T1), the CRP subjects had a significantly higher Digit Span scaled score than the comparison group (CS). There were no other significant differences between the groups at T1 testing. At repeat testing following treatment (T2: approximately 6 months later for the CRP subjects and 6 to 12 months later for the CS subjects), the CRP group exhibited significantly improved scores on all three dependent variables of attention/concentration when compared with the CS group. Paired comparison *t* tests were calculated within groups. There were no significant changes from T1 to T2 in the CS group. The CRP subjects, on the other hand, demonstrated statistically significant improvement from T1 to T2 on Digit Span [t (20) = 2.53, p = .02], Sentence Mem-

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Table 2. Descriptive and effectiveness data for cognitive remediation (CRP) and comparison subjects (CS)

Variable	CRP ($n = 21$)	CS ($n = 10$)
Gender (Male/Female)	13/8	6/4
Age	11.9 (3.7)	10.9 (2.8)
Diagnosis		
Leukemia	8	3
Lymphoma	1	0
Brain tumor	10	6
Osteogenic sarcoma	2	1
Years off treatment	4.0 (3.7)	3.5 (2.7)
Cranial irradiation (cGy)	2270.2 (2441.1)	2450.0 (2537.4)
Verbal IQ	88.9 (8.7) ($n = 16$)	85.9 (14.8) ($n = 9$)
Digit Span		
T1 ($p = .01$)	8.7 (2.8)	5.7 (2.9)
T2 ($p = .0006$)	10.1 (2.9)	5.8 (3.0)
Sentence Memory		
T1	8.1 (2.1)	6.6 (3.3)
T2 ($p = .01$)	9.1 (2.6)	6.1 (3.3)
Continuous Performance Test*		
T1	12.2 (5.7)	14.2 (4.2)
T2 ($p = .01$)	5.5 (6.8)	12.8 (8.0)
Arithmetic		
T1	86.8 (15.3)	80.1 (14.6)
T2	87.9 (14.4)	79.1 (18.0)

*A lower score represents better performance.

ory [t (19) = 2.23, p = 04] and the CPT [t (20) = 5.50, p = .0002]. There was not a significant improvement in arithmetic computational performance for either group. Data were also analyzed using a mixed repeated measures ANOVA design. Within subjects contrasts revealed significant improvement on the CPT over time in the CRP group [$F(1,29) = 11.05$ $p = .002$]. There were significant Time × Group interactions for the CPT [$F(1,29) = 4.76$, $p = .04$] and on Sentence Memory [$F(1,29) = 7.15$, $p = .05$].

Table 3 consists of estimated effect sizes for the attentional and achievement measures. In this analysis a large effect size was obtained for the CPT variable. The CPT was hypothesized to be the most sensitive index of the therapeutic effects of the CRP based on our observations over the course of developing this program (Butler et al., 1999), and this hypothesis was supported. A moderate effect size was characteristic of group differences on the two measures that contained a brief, focused attentional component.

Table 3. Estimation of effect sizes

Measure	Observed difference[1]	Observed standard deviation[2]	Estimated effect size[3]
Digit Span	1.38	2.87	.48
Sentence memory	1.50	2.72	.55
CPT	−5.28	6.31	.84
Arithmetic	1.10	15.40	.12

[1]Difference in change from Time 1 to Time 2 between control and treatment subjects.
[2]Standard deviation at Time 1.
[3]Correlation of measures at Time 1 and Time 2.

DISCUSSION

Over the past decade we have developed and pilot tested a CRP designed to improve attention and concentration skills in children, adolescents and young adults who have been treated for cancer. Many cancer treatments can result in significant cognitive dysfunction which has a negative impact on the individual's quality of life. Our efforts at developing the CRP have been programmatic and evolutionary, and this program is ready for a large-scale evaluation of its effectiveness. The pilot remediation program is of manageable length (i.e. 4 to 6 months) and school absences due to therapy attendance are minimized (i.e. a single 2-hr session per week). At this time, a multicenter Phase III treatment outcome study has begun to assess the effectiveness of the CRP. The pilot data presented are encouraging, but are characterized by potential confounds such as unequal sample size and nonrandom assignment into the treatment condition.

The CRP was specifically designed for individuals with neuropsychological impairment secondary to treatment for pediatric cancer. These children, adolescents and young adults commonly have an attentional disturbance, particularly in the area of maintaining vigilance, and the primary goal of the CRP is to improve cognitive skills in this area. It should be pointed out that without neuropsychological assessment prior to the diagnosis of cancer, we can never be confident that these subjects did not have an attentional disturbance prior to the occurrence of the malignancy and its subsequent treatment. To minimize this possibility, however, we have routinely excluded subjects who had a recognized attentional deficit or learning disability prior to the diagnosis of cancer. Although the CRP contains compartmentalized therapeutic modules, the therapist is also free to discuss other areas of concern with the patient, as long as it does not detract from the remediation exercises and activities. Our experience has been that this individual contact has a beneficial effect on patient socialization, social skills development and self-esteem, which may be associated with nonspecific psychotherapeutic factors stemming from the therapist-patient relationship. We do not, however, have data to support these clinical observations and are now measuring psychological variables on our research participants.

The CRP is an experimental therapeutic method that is a compilation of previously developed approaches, and also additional methods and procedures. This method is an innovative approach in that it is a tripartite combination of (1) drill oriented practice, (2) learning skills and strategy acquisition, and (3) cognitive–behavior therapy. It is presented as a potential means of improving cognitive skills and school performance in children, adolescents and young adults with a history of cancer. We believe that the CRP may also be effective with children who have other forms of attentional difficulties. It is imperative, however, that we first demonstrate the ecological validity of the CRP, and that the treatment has an impact on the participants daily life at school and elsewhere.

Pilot studies are encouraging; however, the preliminary data clearly indicate that further refinement of the CRP is likely to be necessary. Although improvements in attentional disturbances appear to be an attainable goal, it is unlikely that these deficits will be eliminated using the current approach. The pilot data presented on the CRP suggest that strategy acquisition and remediation tend to normalize sustained vigilance attention in many subjects, at least for periods up to 15 min. The data do not, however, indicate that this has a consistent beneficial effort on arithmetic achievement. Obtaining additional 6-month follow-up data on all subjects will help address the possibility of a lag time effect. It may be naive to believe that the relatively brief period of the CRP would immediately affect academic achievement. Furthermore, the WRAT is insensitive to subtle change by its very nature. We are now measuring academic productivity (number of problems attempted) in addition to success, to determine if this is influenced by the CRP. It is also possible that there is considerable individual variability in response to the CRP, and not all children may benefit equally from this type of intervention. Results from continued data collection will eventually be based on a sufficient sample size so that subject variables, such as dose of CRT, age and gender, can be explored as potential moderators on remediation effectiveness. The currently used battery of dependent measures was brief and confounded by other cognitive processes such as language competence and memory. We will also want to include measures obtained from teachers and parents, but blinding these individuals to the participants' treatment condition will be difficult, if not impossible. A final cautionary note should be directed to the fact that our comparison group performed in a slightly more impaired direction at baseline. While we believe this is artifactual, more data will need to be collected. As noted earlier, the groups were heterogeneous in diagnostic composition and this may be a contributory factor to baseline differences. At the same time, however, the fact that the CRP group improved in the face of heterogeneity is supportive of the intervention's external validity.

Another important factor to keep in mind is the involvement of parents. In three of the four instances in which children did not complete the program, our impression was that lack of parent support was responsible. Actively involving the parents in the CRP and providing them with additional problem solving and advocacy skills may further strengthen the overall effectiveness of our intervention. The timing for implementation of the intervention may also be of critical importance. On an intuitive basis it seems likely that providing the CRP soon after the emergence of an attentional disturbance would be of greater benefit, but this will have to be documented empirically. An issue that should also be addressed is treatment adherence. Although our therapists were trained, followed a detailed manual and were supervised weekly, we did not collect quality assurance data on treatment adherence. Future studies should include indices of treatment fidelity. When the CRP was first developed and implemented close to a decade ago, 6 months of weekly therapy was considered a relatively brief intervention framework. This is no longer the case, and there is now pressure on health care providers to shorten treatments. There are realistic financial issues in providing this treatment and, if we can document effectiveness, the next question will be: Can we obtain the same results with a briefer version of the CRP? The development of the CRP has been, and is likely to continue to be, a time-consuming and expensive project. We believe this amount of money and time is wisely spent. Pediatric oncology has been a breakthrough field in medicine. Now that children are surviving cancer in large numbers, it is incumbent on pediatric psychologists to take a major role in designing effective rehabilitation programs. It is also likely that developments in this area will lead to advances that can be shared with other populations of children, adolescents and young adults who suffer an injury to the brain.

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APPENDIX

Examples of Specific Metacognitive Strategies Taught in the CRP

I. Task Preparation Strategies

1. Magic/Special Words

The patient should have at least three words that serve as cues to alert the child/adolescent that they are to do their very best work.

2. Soup Breath

This is a very brief relaxation exercise that can be helpful in preparing the patient to do their very best work. This is an exercise that is very relaxing, and it should also be prescribed as homework.

3. Game Face

This is best used as a sports analogy. Describe the concept of a "game face" to the patient.

4. World Record

The world record strategy is used to encourage the child to perform at his/her highest level. When using this strategy it can be helpful to encourage the child to keep a personal record of his/her own performances.

5. Warm Up My Brain

The child should be taught about brain function at an age appropriate level. The important idea to convey is that his/her brain is activated during a cognitive task. This is a strategy that is very conducive to the use of visual imagery.

II. On Task Strategies

1. Talk To Myself

This is a cognitive-behavioral oriented strategy that should be used to have the child use both self encouraging and self alerting internal dialogues. The patient should continually remind themself what they are supposed to be doing. This strategy serves not only as a self monitoring function, but also as a self alerting process.

2. Mark My Place

Frequently children will lose their place when working with complex visual arrays. If this is the case, the patient can be taught to make small tick marks at the end or beginning of each row in order to not lose his/her place.

3. Start At The Top, One Row At A Time

This is another strategy that is used with visual-spatial stimulus materials. The child may need to be specifically taught to start in the top left corner, and complete the task in a systematic, one row at a time fashion.

4. Look for Shortcuts

The child should be taught to analyze a problem or task and determine the most effective way that it can be completed. The patient should also be encouraged to use the "look for a shortcut" strategy in their everyday life.

5. Time Out/Start Over

The child should be encouraged to self monitor and be aware when he/she is making errors. If a task becomes confusing or the patient begins to become "lost", he/she should learn how to ask the therapist/instructor to please stop, take a brief rest break, and start over.

6. Look At The Floor

Many children engage in self distracting behavior. With these children it can be very helpful to teach them to stare at a blank surface so as not to become distracted.

7. Ask For A Hint

If the child is struggling, they should be taught how to ask for assistance. Many children simply continue to flounder rather than request help.

III. Post Task Strategies

1. Check Your Work

The importance of this time honored procedure cannot be overemphasized. At all times encourage the child to check his/her own work, and the eventual goal of this strategy is for it to be completely internalized.

2. Ask For Feedback

The child should be encouraged to ask the therapist about his/her level of performance, and if there is anything that they could be doing to improve their performance.

3. Reward Yourself

This may be the most important strategy. The child should always reward him/herself for effort.