Direct attention training (DAT) and metacognitive strategy instruction have been employed to treat the cognitive deficits associated with traumatic brain injury (TBI) in children and are supported by an emerging evidence base (e.g., Butler et al., 2008; Galbiati et al., 2009; Luton, Reed-Knight, Loiselle, O'Toole, & Blount, 2011; van't Hooft et al., 2007). The importance of treatment intensity is well established for DAT (Sohlberg et al., 2003), yet restrictions in the delivery and funding of rehabilitation services, the availability of well-trained interventionists, and access by geographic locale remain critical barriers to the provision of intensive services. Computer-delivered treatments that incorporate a home practice component address the gulf between the intensive, daily practice suggested by the efficacy research and these clinical delivery constraints. The purpose of this paper is to (a) review the literature evaluating the integration of DAT and metacognitive facilitation to treat children and adolescents with traumatic brain injury (TBI); (b) present the rationale and description of a computerized program, Attention Improvement Management (AIM); (c) detail the program components; and (d) present outcome data from three pilot participants who completed the intervention. A specific and growing subset of
children with TBI have attention impairments following mild brain injuries or concussions (Schatz & Scolaro Moser, 2011) and served as the pilot participants in this study. Pilot participants demonstrated clinically meaningful improvements on attention outcome measures and generalization of the metacognitive strategies trained within the program to contexts outside of therapy, including both academic and social settings. Though initial results are promising, further research is needed to evaluate the efficacy of the AIM intervention to treat the attention and executive function impairments associated with pediatric TBI.

The cognitive, emotional, and behavioral impairments associated with pediatric traumatic brain injury (TBI) can be devastating, particularly because head injuries are “invisible disabilities” that impact relationships, academic success, and employment potential (Chamberlain, 1995; Limond & Leeke, 2005). In addition, cognitive impairment can become more pronounced in children as they develop (Anderson, Northam, Hendy, & Wrenall, 2001). In children, “there is concern that damage occurring to a developing system may not appear particularly severe at an early age, but that the children will show increasing lags in development and unexpected deficits as they get older” (Sohlberg & Mateer, 2001, p. 60). The possibility of emerging deficits highlights the need for monitoring and intervention in a timely manner. Although a number of different approaches have been developed to ameliorate cognitive deficits associated with TBI in children, direct attention training (DAT) and metacognitive strategy training are supported by the most extensive evidence base. The purpose of this paper is to (a) review the literature supporting the integration of DAT and metacognitive facilitation to treat students with acquired brain injury (ABI) and TBI; (b) present the rationale and description of a computerized program, Attention Improvement Management (AIM); (c) detail the program components, including selection of targeted attention domains, metacognitive strategies, and the home practice regimen; and (d) present outcome data from three pilot subjects who completed the intervention program.

The pilot subjects all had mild TBI due to sports-related injuries. There is growing public awareness about the potential long-term effects of pediatric sports-related concussion, with increasing legislation on education and management (Schatz & Scolaro Moser, 2011). Concussion can cause a mild form of TBI that may or may not involve loss of consciousness and is typically characterized as a temporary condition with a brief period of impairment that is followed by spontaneous recovery (McCrory et al., 2009). The pilot subjects were part of a subgroup of children with sports concussions who had previously typical functioning and chronic cognitive deficits that did not resolve. Given the absence of literature on remediation of cognitive deficits post sports-related concussion, it is useful to turn to the pediatric TBI literature for evidence regarding the efficacy of different intervention techniques.

**Direct Attention Training (DAT) and Metacognitive Strategy Training**

DAT and metacognitive strategy training have an extensive evidence base in the adult cognitive rehabilitation literature (e.g., Kennedy et al., 2008; Sohlberg et al., 2003). DAT aims to improve the underlying attention deficit by targeting specific attention skills such as sustained attention, working memory, and shifting from one task to another (Sohlberg et al., 2003). The premise is that attentional abilities can be improved by providing structured opportunities for exercising particular aspects of attention. Treatments typically involve having clients complete a series of repetitive drills or exercises that are designed to provide opportunities for practice on tasks with increasingly greater attentional demands to improve functioning (Sohlberg & Mateer, 2001). For children, DAT has been found effective with a number of pediatric groups including children with attention deficits, survivors of cancers affecting the central nervous system (Butler et al., 2008), attention deficit hyperactivity disorder (ADHD; Penkman, 2004), and children with developmental learning disabilities (Stevens, Fanning, Coch, Sanders, & Neville, 2008). Another effective approach with this population is metacognitive strategy instruction.
**Metacognitive strategy training** refers to teaching self-monitoring, self-management, and goal-setting strategies to support generalization of improved attention and executive function skills to academic, social, and typical daily living tasks. There is considerable empirical support for the efficacy of training in reflecting on one's thoughts and actions and using that information to regulate one's learning and behavior (Kennedy et al., 2008). When paired with attention training, metacognitive strategy instruction typically emphasizes facilitating efficient allocation of cognitive resources by providing feedback, goal-setting, and self-awareness enhancement. Recent reviews (Mooney, Ryan, Uhing, Reid, & Epstein, 2005; Reid, Trout, & Schartz, 2005) provide strong support for metacognitive strategy training to improve target behaviors in children with ADHD and social and emotional behavior disorders. However, data regarding their efficacy for children with TBI is limited.

**Evidence**

Recent studies have investigated the efficacy of attention training and metacognitive strategy instruction to treat pediatric patients with attention deficits due to ABI. Galbiati and colleagues (2009) completed a study on 65 patients (with 25 as non-treated controls) with TBI, ages 6–18 years, utilizing a computerized DAT intervention (Rehacom [Schuhfried, 1996] and Attenzione e Concentrazione [Di Nuovo, 1992]) along with their clinician-delivered cognitive rehabilitation intervention. The computerized DAT program included tasks designed to address vigilance, response behavior, sustained attention, selective attention, divided attention, and shifting. Participants also received metacognitive strategy instruction, which the researchers hypothesized would improve participants’ awareness of attention (i.e., *meta-attention*) and cognitive control. After intervention, treated students showed significant improvements on the Continuous Performance Test II Overall Index (CPT II; Conners, 2000), as well as reductions in impulsiveness and omission errors when compared to controls. Additionally, students who received the intervention demonstrated significant improvement on measures of adaptive behavior including daily living skills, social skills, and communication (as reported by parents) at post-testing and at the one-year follow-up, compared to controls.

Butler and colleagues reported similar findings from their multicenter, randomized clinical trial of an intervention for childhood cancer survivors with attention impairments (Butler et al., 2008). Of a sample of 161 children, two-thirds were randomly assigned to their cognitive remediation program (CRP). These participants received up to 20 two-hour weekly sessions, over four to five months, that combined attention exercises of increasing task difficulty using a modified version of Attention Process Training (Sohlberg, Johnson, Paule, Raskin, & Mateer, 1999) with strategy instruction and cognitive-behavioral support. Metacognitive strategies targeted task preparedness, on-task performance, and post-task activities, while the cognitive-behavioral aspect of CRP targeted children’s ability to withstand distraction via self-talk. Children in the CRP showed significant increases in academic achievement, as well as improvement in attention and fewer cognitive problems reported by parents on the Conners’ rating scales (Conners, 1997), compared to their pre-treatment ratings. However, compared to the waitlisted control group, the children in the CRP group did not demonstrate improvement on neuropsychological functioning, including working memory and vigilance.

Luton and colleagues (2011) evaluated an abbreviated version of Butler and colleagues’ (2008) CRP on eighteen 6–15-year-old children with a range of neurological conditions resulting in attentional problems. Their objective was to determine the effectiveness of a shorter version of the established CRP. Participants received six one-hour CRP sessions, twice a week, over a three-week period, compared to the longer treatment program delivered in the initial trial by Butler and colleagues. Like the Butler et al. (2008) study, participants were trained in metacognitive strategies that targeted task readiness and on-task performance and instructed to use the trained strategies during sessions as well as on various homework tasks. The abbreviated CRP was associated with significant improvements on impairment-based measures of attention related to selective, alternating, and divided attention skills from pre- to post-
treatment. In addition, parents reported improvements from pre- to post-treatment on the Attention Questionnaire (Sohlberg et al., 1999), which reflects the frequency with which attention problems occur. They did not compare treated children to a control group. Similar to previous studies, their results, while not entirely conclusive, are encouraging.

Van’t Hooft and colleagues (2007) also examined the impact of DAT and strategy instruction on children (ages 9–17 years) with ABI. Thirty-eight children were randomly assigned into treatment and control groups. Participants in the treatment group received the Amsterdam Memory and Attention Training for Children program (Amat-c, Hendriks & van den Broek, 1996), which consisted of strategy instruction for carrying out daily tasks and academic achievement, in addition to specific attention and memory stimulation. The exercises were performed with a “coach” (typically a teacher or parent) for 30 minutes, 6 days per week, for a period of 17 weeks. Like the intervention implemented in the Butler et al. (2008) and Luton et al. (2011) studies, the attention and memory exercises gradually increased in difficulty. Students in the treatment group demonstrated significant improvement in sustained and selective attention as well as verbal working memory on a battery of standardized assessments at post-test, as well as six months post treatment, when compared to control students. However, there were no differences in performance on reaction time tests between the students in the treatment and control groups.

All four of the existing studies evaluating the efficacy of DAT and strategy instruction in children with ABI (Butler et al., 2008; Galbiati et al., 2009; Luton et al., 2011; van’t Hooft et al., 2007) provide initial support for integrating both approaches when working with students with TBI or ABI. However, in each of these studies, the metacognitive strategy training was delivered by a clinician. While this may be an ideal way to deliver interventions, issues related to availability of well-trained interventionists, as well as access to these interventionists by the families’ geographic locale, remain critical stumbling-blocks to provision of services in a timely manner (Galbiati et al., 2009; Kesler, Lacayo, & Jo, 2011).

Another key factor is the intensity of intervention delivered in each of the studies. Participants in the Galbiati et al. (2009) study received the greatest dosage and treatment intensity, with 45-minute sessions delivered four times a week over a six-month period. In the Butler et al. (2008) and van’t Hooft et al. (2007) studies, the intervention was approximately four months in duration. Participants in Butler and colleagues’ study received two-hour sessions one to two times per week, while the participants in van’t Hooft and colleagues’ study received 30-minute sessions six times a week. Though the importance of treatment intensity is well established for DAT (Sohlberg et al., 2003), a number of barriers make providing the recommended dosage of therapy unrealistic or unfeasible. Restrictions in the delivery and funding of rehabilitation services, the availability of well-trained interventionists, and client access by geographic locale remain critical barriers to the provision of intensive services. Technology-delivered intervention that incorporates home practice addresses the need for intensive, daily practice and offers a solution to these clinical delivery constraints.

**Attention Improvement Management (AIM) Program**

Mounting evidence supports the potential utility of both attention and strategy training to address the attention and executive functioning difficulties arising from pediatric ABI. Given the pervasive nature of secondary attention difficulties, an intervention integrating both process and strategy training is likely to result in greater improvements than an intervention including only one of these approaches. DAT builds on the emerging literature on experience-dependent neural plasticity (i.e., repeated practice allows new pathways to be established in the brain). However, it has been criticized as decontextualized, thereby resulting in a lack of generalization to new settings and situations (Park, Proulx, & Towers, 1999). In response to these concerns, AIM integrates attention training with the use of metacognitive strategies to ensure that the child can apply these skills across settings and situations.
AIM is a fully computer-delivered intervention. Clinicians are led through a computer-based intake procedure that assists in the selection of attention training tasks and metacognitive strategies tailored to the needs of the child. This initial program can be used for treatment in the clinic as well as for home practice. AIM has a built-in home practice component with the capacity to record and send student performance from his/her practice sessions completed at home to the clinician’s computer for review. The emphasis on home practice addresses the gulf between clinical delivery constraints, such as access to skilled interventionists or limited rehabilitation services, and the importance of regular practice to improve outcomes.

Description

The attention tasks in the AIM program consist of graded drills organized by the attentional domains they stimulate. Consistent with Sohlberg and Mateer’s (2010) revised model of attention integrating consideration of executive functions, the attention components are divided into two main types: basic sustained attention and attention requiring executive control, which includes selective attention, working memory, suppression, and alternating attention. This clinical model of attention “allows clinicians to identify discrete attention components that may be differentially impaired, and to then intervene on select areas of concern” (Sohlberg & Mateer, 2010, p. 7).

Metacognitive strategy training is integrated with the attention drills in two ways. First is the direct training of strategies that increase attention and engagement. These include strategies such as reauditorization, visualization, self-talk, breathing and focusing, double-checking performance, and using an agenda to track progression through tasks. The AIM program generates individualized strategies for each user based on responses to a computerized intake process, which is designed to target strategies that match a student’s impairment profile and specific needs. Strategies are selected and the program reviews and prompts strategy use before and after the attention exercises. Additionally, metacognitive skills are also facilitated by prompting students to self-reflect. After each exercise, the participant rates his or her motivation and effort for the task. The data are recorded and can be shared with the participant by the clinician to provide feedback and support self-awareness and monitoring.

Overview

Program Set Up: The AIM interface is designed to allow standardized delivery of attention and strategy training matched to an individual student’s profile. The interface leads the therapist (or researcher) through an intake process where he/she answers questions about the student’s attentional functioning (see Figure 1). Based on the therapist’s information, the program will offer a recommended group of exercises. The therapist can override or modify these recommendations as necessary, but the program is designed to be semi-manualized to address the range of clinician skills. Similarly, the initial intake process guides the therapist in selecting metacognitive strategies. The therapist collaborates with the student to individualize the strategy to increase student motivation, as illustrated in Figures 2 and 3. The therapist then selects a prompting level (based on the student’s need for support) that determines the frequency and timing for delivering prompts to use the strategies. At any time, the therapist can edit the attention exercises, strategies, or levels of support in response to student performance.
Figure 1. AIM Computerized Intake Assessment on Attention Domains

Figure 2. AIM Computerized Selection of Strategy Instruction
Figure 3. Personalizing the Strategy for the Student

![Image of software interface for personalizing strategies]

**Options for Selected Strategies**

- Personalize the wording for the strategies you selected on the previous screen.
- If you are unsure about the support level, you may leave it on the default setting.

**Attention Domain Examples**:
- Sustained Example: When attention starts to fade, tell self your motivation words - 'keep on'.
- Personalized Strategy Wording: Finish!

**Support Level**:
- Full
- Moderate
- Faded

![Print Strategy Worksheet]

Continue
Back

Figure 4. Example of an AIM Program Targeting Various Attentional Domains (e.g., Sustained, Selective Attention) Combined With Metacognitive Strategy Facilitation (e.g., Repeating Information)

![Image of AIM program for Sarah]

**AIM Program for Sarah**

- Estimated length of AIM program: 30 minutes
  - Sustained Attention Tasks:
    - Listening for 1 Letter in a Word with female clinician (slow)
  - Selective Attention Tasks:
    - Listening for 1 Number with Environmental noise distraction and female clinician (slow)
  - Working Memory Tasks:
    - Matching Animals (2-back) (slow)
    - 5-4 Word Sentences (Alphabetical) with female clinician
  - Suppression Tasks:
    - Serious-Silly Intonation with button response (slow)
  - Alternating Attention Tasks:
    - Big-Small Word Size (slow)

If you would like to edit/change any of the above tasks, click on the Edit Tasks button.

Edit Tasks
Continue
Back
Session Organization: Each AIM session is organized into three sections. First, the session agenda is presented, which includes a list of the attention exercises to be completed, a review of homework/prior progress, and strategy review and goal-setting for that session (“Pregame” Activities). The second section involves the delivery of the attention exercises and strategy practice with self-reflection embedded into the exercises (“In the Game” Activities). The third section is the wrap-up, with reinforcement, homework assignment, and future goal-setting (“Postgame” Activities). The majority of the session (30–40 minutes of the one-hour session) is spent completing the attention exercises. As shown in Figure 4, a typical AIM session consists of exercises within specific attentional domains and personalized strategy instruction to increase attention and task engagement. Metacognitive skills are also facilitated in the pre- and post-game activities by having the student set goals and reflect on his or her performance and the usefulness of specific strategies.

Home Practice: AIM includes a USB drive that allows students to practice at home. The home practice program prompts the students to use their strategies, but most of the time is spent completing the attention exercises while self-monitoring their effort and motivation. Performance data is saved on the USB and either sent to the server or, if the student does not have Internet access, is saved on the USB homework drive to be downloaded by the therapist during the next clinic session. Home sessions typically last 30–40 minutes and can be completed as often as the clinician and student like. In general, AIM is expected to last 10–12 weeks, with a weekly clinic session and students completing two to three home practice sessions per week.

To pilot our intervention and establish usability with the pediatric/adolescent TBI population, we ran three participants through the program for varying lengths of time based on their availability. The participants were referred to our cognitive rehabilitation clinic and all had cognitive impairments resulting from sports-related injuries. They represent a specific and growing subset of students with mild TBI, thus, we were interested in evaluating their response to AIM. The following section describes these three participants with mild TBI who completed either seven or ten weeks of AIM. A description of each of the participants is presented, including his or her injury and attention profile, individualized AIM program, and outcomes on standardized assessments of attention and executive functioning.

Case Report

Participants

Participants were referred to our cognitive rehabilitation clinic from a local sports medicine and pediatrics physician. Selection criteria included:

- Documented TBI
- Between ages 9 and 17 years
- Persistent attention and/or executive functioning difficulties interfering with social and/or academic performance
- Ability to tolerate cognitively demanding tasks delivered via the computer
- Transportation to the University of Oregon Clinic for assessment and treatment sessions

Following parental and participant consent, participants were administered a cognitive battery including standardized tests assessing attention and executive functioning. The same battery was administered at the end of intervention. The assessment battery included the CPT II (Conners, 2000), the Test of Everyday Attention (TEA; Robertson, Ward, Ridgeway, & Nimmo-Smith, 1994) or the Test of Everyday Attention for Children (TEA-Ch; Manly, Robertson, Anderson, & Nimmo-Smith, 1999), and selected subtests from the Delis-Kaplan Executive Function System (D-KEFS; Delis, Kaplan, & Kramer, 2001). It is worth noting that two students (LB and BK, see below) were given the TEA rather than the TEA-Ch, despite their ages being

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excluded from the TEA’s normative sample. This decision was made to maximize the students’ motivation by using age-appropriate test stimuli. A description of three adolescent participants, including their attention profile, their individualized AIM programs, and outcomes following the intervention, is provided in Table 1 below.

Table 1. AIM Program Summary for Pilot Participants

<table>
<thead>
<tr>
<th>Participant</th>
<th>Attentional Domains Targeted in AIM Program</th>
<th>Metacognitive Strategies Targeted in AIM Program</th>
<th>Intervention Duration</th>
<th>Clinic Sessions</th>
<th>Average Home Practice Sessions/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>LB</td>
<td>Basic Sustained: 24%</td>
<td>Repeating or clarifying information</td>
<td>7 weeks</td>
<td>7/7</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>Selective: 5%</td>
<td>Re-engaging in middle of task</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Working Memory: 34%</td>
<td>Personalized wording: “Refresh”</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Suppression: 17%</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Alternating: 20%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PW</td>
<td>Basic Sustained: 28%</td>
<td>Repeating or clarifying information</td>
<td>7 weeks</td>
<td>10/14</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>Working Memory: 39%</td>
<td>Mental imagery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Suppression: 33%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BK</td>
<td>Basic Sustained: 18%</td>
<td>Deep breathing</td>
<td>10 weeks</td>
<td>9/10</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>Selective: 15%</td>
<td>Internal self-talk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Working Memory: 45%</td>
<td>“Finish!”</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Suppression: 7%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alternating: 15%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LB

LB is a 16-year-old high-school junior, approximately two years post-concussion from a football injury and a second concussion from an accidental elbowing the following year, resulting in retrograde and anterograde amnesia and persistent headaches.

Attention Profile: Although his CT scan was normal, at the initial evaluation, LB complained of difficulty concentrating, particularly during class lectures and while taking tests. Results of baseline testing suggested moderate to severe impairments in attention, particularly alternating and divided attention, regardless of whether tasks were presented auditorily or visually.

AIM Program: The intake process used information from LB’s self-report and initial testing to individualize his intervention in selecting attention and metacognitive strategies. As illustrated in Table 1, tasks in each of the five attentional domains were targeted across LB’s seven-week intervention. Given the importance of working memory in carrying out alternating and divided attention tasks and its relevance to classroom activities such as listening to a lecture while taking notes, the primary domain targeted in LB’s program was working memory. Two metacognitive strategies were trained within his AIM program: repeating or clarifying information and re-engaging in the middle of a task. Training LB to repeat or clarify information was intended to ensure he understood a particular task before beginning. The re-engaging strategy was selected based on LB’s self-report of his attention “drifting off” during lectures and tests; this pattern was confirmed by his performance on several of the basic sustained attention tasks within the first weeks of intervention. Personalized wording (i.e., “refresh”) was substituted for the generic wording within the program, and the frequency with which the program delivered prompts to use the strategies was faded until LB could independently describe how and when to use the strategies both in and outside of the clinic sessions. Of note, during the sixth week of the program, LB reported using his “refresh”
LB attended seven out of seven clinic sessions and practiced an average of 1.6 times per week at home.

**Outcomes:** LB improved most notably in the domains of alternating and divided attention, both of which rely heavily on working memory, the primary domain targeted within his AIM program. As shown in Table 2, he improved over one standard deviation on subtests of the TEA and D-KEFS corresponding with executive attention and cognitive flexibility. As shown in Table 3, his gains in these attentional domains were clinically significant, with scores consistent with moderate and profound deficits at pre-treatment improving to scores in the average range relative to the normative sample at post-treatment. LB reported improvements in his ability to concentrate in class, on tests, and during homework assignments. Both he and his parents endorsed the AIM program as helpful and expressed satisfaction with the home-practice component given their long (three-hour) commute to the clinic.

**PW**

PW is a 15-year-old high-school student who presented with persistent cognitive and somatic symptoms following a concussion suffered during a snowboarding accident five months prior to her initial evaluation.

**Attention Profile:** Although she did not report loss of consciousness during the accident, she complained of several residual symptoms of concussion, including intense headaches, fatigue, and sensitivity to light and noise, as well as academic difficulties related to paying attention during class and completing homework assignments. PW also reported that her relationships with friends suffered after her injury due to her forgetting scheduled social activities and details of previous events. Results of baseline testing suggested moderate impairments in attention and working memory, with notable difficulty in tasks requiring divided attention or cognitive flexibility (see Tables 2 and 3).

**AIM Program:** After completing the intake process, attention exercises designed to target sustained attention, working memory, and suppression were selected. The strategies selected were repeating or clarifying information and mental imagery. For example, during “Pre-game” activities, PW was encouraged to repeat or paraphrase instructions for a task before beginning the task. As she mastered this strategy within the session tasks, she was encouraged to use this same strategy outside of clinic by repeating conversations with friends in her head to improve her recall. She utilized mental imagery to mentally focus before beginning a task. After the first two weeks of therapy, her clinic sessions were increased to twice a week for a total of seven weeks, which occurred during her summer break. PW completed a combined total of 19 AIM sessions in clinic and via home practice (see Table 1).

**Outcomes:** As illustrated in Table 2, PW demonstrated improvements on several subtests of the TEA-Ch. Gains were clinically meaningful, with scores improving from moderate to low-average performance at pre-treatment to average to high-average performance compared to the normative sample after intervention (see Table 3). It is notable that PW made gains across the various attentional domains, particularly executive attention and suppression, which correspond to the domains targeted in her individualized AIM program. In addition, PW reported improved recall of events following the AIM intervention. For example, she reported experiencing less forgetting episodes, such as forgetting which friends attended social events. She also reported using metacognitive strategies trained in sessions in her everyday life.

**BK**

BK is a 16-year-old high-school junior who presented with static migraines and cognitive difficulties following a concussion suffered during football practice, two months prior to his initial evaluation. Like the two previous participants, BK did not report loss of consciousness during his injury. BK completed approximately two months of cognitive rest after his injury and prior to participating in the AIM intervention.
Attention Profile: BK’s primary concern was his ability to attend to conversations and information presented in class. He also reported difficulty with reading retention since his injury. Results from initial testing suggested minimal to moderate deficits in executive attention, including divided attention and suppression (see Table 2).

AIM Program: Like the other two participants, an individualized AIM program was developed, based on results from BK’s cognitive evaluation and the participant’s self-report of attention and memory difficulties impacting his school performance in completing the intake process. As depicted in Table 1, tasks that targeted each of the attentional domains were selected. However, the majority of tasks were chosen to stimulate working memory, given the role of working memory in higher level executive attention skills, as well as BK’s complaint of difficulty holding onto information presented in class and while reading. Two metacognitive strategies were integrated into BK’s program: deep breathing and internal self-talk, with personalized wording (i.e., “Finish!”), which the participant associated with his respected football coach. BK completed a rigorous ten-week program, attending nine out of ten clinic sessions and practicing an average of two to three times per week at home.

Outcomes: Results of post-treatment testing suggested improvements in executive attention and suppression, with corresponding improvements of at least one standard deviation from pre- to post-testing on the CPT-II and subtests of the D-KEFS. Gains were clinically significant, as scores following treatment were consistent with average to above-average performance relative to the normative sample (see Tables 2 and 3. Both BK and his parents endorsed the AIM program as helpful. BK reported improved ability to listen to lectures while taking notes and the ability to read and retain more written material following the intervention.
Table 2. Pre-Post Performance Across Pilot Subjects

<table>
<thead>
<tr>
<th></th>
<th>LB Pre</th>
<th>LB Post</th>
<th>PW Pre</th>
<th>PW Post</th>
<th>BK Pre</th>
<th>BK Post</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sustained Attention</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPT-II Omissions</td>
<td>46.3</td>
<td>52.3</td>
<td>48.6</td>
<td>43.8</td>
<td><strong>54.3</strong></td>
<td><em>44.3</em></td>
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<tr>
<td>TEA Map Search (1st minute)</td>
<td>9</td>
<td>6</td>
<td>NA</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEA Visual Elevator: Accuracy</td>
<td>11</td>
<td>13</td>
<td>---</td>
<td>---</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>TEA Visual Elevator: Timing</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEA-Ch Score: Total Correct</td>
<td>---</td>
<td>---</td>
<td>6</td>
<td>*13</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>Selective Attention</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEA Elevator Counting w/distraction</td>
<td>6</td>
<td>7</td>
<td>---</td>
<td>---</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>TEA-Ch Sky Search: Correct Targets</td>
<td>---</td>
<td>---</td>
<td>14</td>
<td>11</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>TEA-Ch Sky Search: Attention Score</td>
<td>---</td>
<td>---</td>
<td>8</td>
<td>8</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>Alternating Attention</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEA Elevator Counting w/reversal</td>
<td>3</td>
<td>*11</td>
<td>---</td>
<td>---</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>TEA-Ch Creature Counting: Total</td>
<td>---</td>
<td>---</td>
<td>6</td>
<td>*13</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>TEA-Ch Creature Counting: Timing</td>
<td>---</td>
<td>---</td>
<td>9</td>
<td>10</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>Divided Attention</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEA Telephone Dual Task Decrement</td>
<td>10</td>
<td>11</td>
<td>---</td>
<td>---</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>TEA Lottery</td>
<td>13</td>
<td>13</td>
<td>---</td>
<td>---</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>TEA-Ch Sky Search DT: Decrement</td>
<td>---</td>
<td>---</td>
<td>1</td>
<td>*9</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>TEA-Ch Score DT: Total Correct</td>
<td>---</td>
<td>---</td>
<td>3</td>
<td>*8</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>TEA-Ch Code Transmission: Total</td>
<td>---</td>
<td>---</td>
<td>5</td>
<td>*10</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>D-KEFS Trail Making Test: Combined Number/Letter Sequencing</td>
<td><strong>1</strong></td>
<td>*8</td>
<td>9</td>
<td>9</td>
<td><strong>4</strong></td>
<td><em>10</em></td>
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<tr>
<td>D-KEFS Tower: Total Achievement</td>
<td>11</td>
<td>15</td>
<td>11</td>
<td>13</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td><strong>Suppression</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEA-Ch Walk Don’t Walk</td>
<td>---</td>
<td>---</td>
<td>7</td>
<td>8</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>D-KEFS Word Inference: Combined Naming/Reading</td>
<td>9</td>
<td>11</td>
<td>10</td>
<td>11</td>
<td><strong>5</strong></td>
<td><em>12</em></td>
</tr>
<tr>
<td>CPT-II Commissions</td>
<td>46.74</td>
<td>51.60</td>
<td><strong>66.2</strong></td>
<td>*48.9</td>
<td>64.9</td>
<td><em>51.0</em></td>
</tr>
</tbody>
</table>

*Note.* Standardized scores reported; *T* Scores from CPT-II, Scaled scores from TEA and TEA-Ch, Composite Score from the D-KEFS. * indicates ≥1 SD improvement in *T* Score (10 points) or ≥1 SD in SS (5 points).
Table 3. Clinically meaningful changes per attentional domain and modality (i.e., auditory or visual) with corresponding neuropsychological measures.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Attentional Domain and Modality</th>
<th>Neuropsychological Measure</th>
<th>Clinical Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>LB</td>
<td>Alternating attention: Auditory</td>
<td>TEA Elevator Counting w/Reversal</td>
<td>Moderate → Average</td>
</tr>
<tr>
<td></td>
<td>Divided attention: Visual</td>
<td>D-KEFS Trail Making Test</td>
<td>Profound → Average</td>
</tr>
<tr>
<td>PW</td>
<td>Sustained attention: Auditory</td>
<td>TEA-Ch Score</td>
<td>Low avg → High avg</td>
</tr>
<tr>
<td></td>
<td>Alternating attention: Visual</td>
<td>TEA-Ch Creature Counting</td>
<td>Low avg → High avg</td>
</tr>
<tr>
<td></td>
<td>Divided attention: Visual</td>
<td>TEA-Ch Sky Search DT: Decrement</td>
<td>Profound → Average</td>
</tr>
<tr>
<td></td>
<td>Divided attention: Auditory</td>
<td>TEA-Ch Score DT</td>
<td>Moderate → Average</td>
</tr>
<tr>
<td></td>
<td>Executive attention/WM: Auditory</td>
<td>TEA-Ch Code Transmission</td>
<td>Borderline → Average</td>
</tr>
<tr>
<td></td>
<td>Suppression</td>
<td>CPT-II Commissions</td>
<td>Average → Superior</td>
</tr>
<tr>
<td>BK</td>
<td>Sustained attention: Auditory</td>
<td>CPT-II Omissions</td>
<td>Average → Average</td>
</tr>
<tr>
<td></td>
<td>Divided attention: Visual</td>
<td>D-KEFS Trail Making Test</td>
<td>Borderline → Average</td>
</tr>
<tr>
<td></td>
<td>Suppression</td>
<td>D-KEFS Word Inference</td>
<td>Borderline → Average</td>
</tr>
<tr>
<td></td>
<td>Suppression</td>
<td>CPT-II Commissions</td>
<td>Average → Superior</td>
</tr>
</tbody>
</table>

**Discussion**

The AIM program builds off the established evidence base for attention and metacognitive interventions for the pediatric TBI population; however, it is explicitly designed to integrate these approaches in a manualized, computer-administered intervention. As a whole, the participants in prior studies responded positively to the specific interventions that had both DAT and strategy instruction, with improvements reported on cognitive assessments (Galbiati et al., 2009; Luton et al., 2011; van’t Hooft, 2005) and parent report of decreased attention difficulties (Butler et al., 2008; Galbiati et al., 2009). Similarly, the three participants who piloted our AIM program demonstrated improvements on measures of attention and executive functioning that corresponded to the primary attentional domains targeted by the intervention. Of equal import, participants demonstrated generalization of the metacognitive strategies trained within the program to contexts outside of the clinic, including both academic and social settings.

While the therapy components of our intervention are consistent with prior interventions that deliver DAT and metacognitive instruction, the AIM program has the potential to extend current practice in a number of ways. First, AIM is a computerized program that overtly integrates DAT with self-regulation and strategy instruction. Given the critique of DAT as decontextualized (e.g., Park et al., 1999; Peach, 2012), integrating strategy use within the direct skills training was intended as a way to ensure students would be able to apply the strategies across settings and situations. Second, AIM can be personalized. AIM was designed with the ability to create a program of attention tasks and strategies that match the needs and personality of the student to increase motivation and outcomes. Pilot participants demonstrated attentional improvements in the same domains targeted by the AIM program. This is consistent with the finding that specific attention functions improve when specific
training is received for that function (Sturm, Willmes, Orgass, & Hartje, 1997). Finally, given the importance of treatment intensity for a number of rehabilitation interventions (e.g., Cherney, Patterson, Raymer, Frymark, & Schooling, 2008; Lee, Kaye, & Cherney, 2009), the home practice component of AIM offers the ability to increase the intensity and dosage of treatment, particularly for clients whose access to services is limited by geographic locale. Relatedly, by semi-manualizing the intervention, there is the potential for using the program in school settings under the direction of a speech-language pathologist, which may increase treatment intensity as well as provide access to the program to children that may not have computers in the home.

Although initial outcomes from our pilot participants are promising, a large scale, randomized-controlled trial is needed to evaluate the efficacy of the intervention for ameliorating the attention and executive function impairments associated with pediatric and adolescent TBI. In addition, our pilot participants presented with mild TBI or persistent post-concussive symptoms secondary to sports-related injuries. This is a growing population, and further research is needed that includes participants with a range of etiologies and severity of injury to determine candidacy for this intervention. With strong evidence to support its utility, AIM has the potential to be used beyond the clinic environment and eventually within school settings, given the manualization of the clinical experience. Considering the high incidence of TBI, including sports-related injuries, there is a pressing need for cost-effective interventions like AIM that can be delivered in less specialized settings (e.g., schools, home), without sacrificing the individualized nature of treatment delivered by a cognitive rehabilitation professional.

**Acknowledgments**

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**Authors**

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*Mckay Moore Sohlberg* is the Hedco Endowed Professor in the Communication Disorders & Sciences program at the University of Oregon. Her work in developing and evaluating cognitive rehabilitation programs for adolescents and adults with brain injury is well known internationally. She has authored numerous journal articles, two leading texts in the
field, and a number of widely used evidence-based clinical programs. Sohlberg has been the Principal Investigator on a number of funded projects developing methods to help people with chronic long-term impairments following brain injury integrate into the community, particularly through the use of assistive technology.

Shari Wade is a pediatric rehabilitation psychologist and professor at Cincinnati Children’s Hospital Medical Center and University of Cincinnati College of Medicine. She is director of the Rehabilitation Research and Training Center for Pediatric TBI Interventions, which is supported by the National Institute on Disability and Rehabilitation Research. Wade has engaged in research on recovery from TBI in children for over two decades. Her research interests include the effects of TBI on families, the relationship of social environmental factors to child recovery, and investigation of cognitive-behavioral and family interventions to facilitate child and family adaptation.

References


