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A Pilot Study Evaluating Attention and Strategy Training Following Pediatric Traumatic Brain Injury

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The prevalence of impairments in attention, working memory and executive functions associated with traumatic brain injury and developmental childhood diagnoses has resulted in increased research to identify effective treatments. The use of a broad based approach that combines both strategy training (domain specific training) and repetitive drill practice (domain general training), has been investigated in the acquired brain injury population with some promising initial findings although methodological issues and demonstration of transfer of training is challenging. This paper describes a pilot study, evaluating an integrated intervention, Attention Improvement Management (AIM) in eleven participants with cognitive processing impairments due to traumatic brain injury. The paper explores the therapy components that appear to be critical to achieving meaningful improvements in attention, working memory and executive functions using this hybrid approach. The results of the pilot study are analyzed to identify the clinical decisions and behaviors required by clinicians implementing even a highly proceduralized computer intervention such as AIM, in hopes of guiding current practice and improving future research investigations.

Keywords: cognitive training, pediatric acquired brain injury, attention training, working memory training

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Impairments in attention, working memory (WM), and executive function (EF) are among the most frequently reported symptoms by parents and teachers following pediatric acquired and developmental cognitive impairments (Diamond, 2012; Max et al., 2005). Disruption of these critical cognitive processes are responsible for a wide range of academic and adjustment issues (Diamond, 2012; Holmes, Gathercole, & Dunning, 2009; Raghubar, Barnes, Prasad, Johnson, & Ewing-Cobbs, 2013). These findings are not surprising considering that atten-

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tion, WM, and EFs underlie most higher order cognition, and that the networks subserving these processes are widely distributed and highly integrated (Klingberg, 2010).

Numerous conceptual frameworks attempt to define these key cognitive constructs and describe their contributions to information processing. In general, attention is considered a strong modulator of cognition and affect and is used to refer to the processes that allow a continued and selective focus on specific aspects of our environment (Posner & Rothbart, 2007; Rabipour & Raz, 2012; Sohlberg & Mateer, 2001). WM is the system that mediates temporary storage and modification of incoming information, as well as protection from interference (Levin et al., 2007; Melby-Lervåg & Hulme, 2013). EFs are the abilities that allow us to allocate or control our attentional resources (Anderson & Catroppa, 2005). The relationship between EF and WM is described variably in the literature. For example, Diamond (2012) describes WM as one of three core EFs, along with inhibition and cognitive flexibility. Some researchers describe WM capacity as synonymous to EF (Melby-Lervåg & Hulme, 2013), whereas other researchers conceptualize WM as related to, but distinct from, EFs (Klingberg et al., 2005; Schmiedek, Lövdén, & Lindenberger, 2010).

EF skills emerge in early childhood and continue to develop through adolescence and young adulthood (Denckla & Reiss, 1997). Consistent with the nonlinear nature of neural development, certain components of EF, such as response inhibition, are established in early childhood, whereas more complex problem solving and planning skills continue to mature throughout adolescence (Anderson, Anderson, Northam, Jacobs, & Catroppa, 2001; Klenberg, Korkman, & Lahti-Nuuttila, 2001). Because EF skills and the corresponding neural regions continue to develop through adolescence, they may also serve as viable targets for intervention to improve executive attention and problem solving (Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005; Wade, Carey, & Wolfe, 2006).

The prevalence of impairments in attention, WM, and EF associated with acquired brain injury and other developmental diagnoses (e.g., attention-deficit/hyperactivity disorder; ADHD) has resulted in increased research to identify effective treatments (Bryck & Fisher, 2012). While there are several intervention programs with exercises exclusively targeting WM (Klingberg, 2010; Morrison & Chein, 2012), others address a broad range of cognitive functions, including attention and EFs (Bryck & Fisher, 2012; Jolles & Crone, 2012). Intervention research to date has primarily focused on pediatric populations with developmental conditions such as ADHD. While there are a number of commonalities in the cognitive symptomatology between developmental and acquired conditions, such as traumatic brain injury (TBI), there are some important differences. Factors related to recovery following an acquired injury and the heterogeneity produced by imposing highly individualized injuries on a uniquely developing system make it difficult to group the two populations in treatment efficacy studies. For example, one of the characteristics of children with TBI is variability in performance across tasks and over time.

Research Evidence in Populations With Developmental Conditions

This article explores the implementation of a direct intervention approach designed to improve attention, WM, and EF in children with TBI that integrates drill-based attention training practice with strategy instruction. A small number of studies evaluating this hybrid approach have started to appear in the pediatric TBI rehabilitation literature in the past 8 years (e.g., Galbiati et al., 2009; Luton, Reed-Knight, Loiselle, O'Toole, & Blount, 2011). More prolific has been the evaluation of interventions to improve cognitive processing in the developmental pediatric literature. Several reviews have compared drill-based attention training practice (also termed core, domain-specific, and implicit training) with strategy instruction (also termed cognitive instruction, domain-specific, and explicit training; Epstein & Tsal, 2010; Klingberg, 2010; Morrison & Chein, 2012).

Morrison and Chein (2012) provide one of the most comprehensive reviews evaluating the direct treatment of WM and EF in the pediatric literature. They provide a theoretical rationale that suggests that domain-specific training (strategy instruction) would be most helpful for maintenance and rehearsal of target information, whereas domain-general (practice exer-

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cises) would be most useful for improving encoding and retrieval of information by increasing such mechanisms as attentional control and reducing interference. They review studies evaluating the efficacy of strategies such as visual imagery, elaborative encoding, and chunking and conclude that domain-specific training is helpful for circumventing the limitations of WM rather than increasing capacity or efficiency, but is limited to near transfer or performance on trained tasks or tasks highly similar to the trained tasks. Other reviews have focused on evaluations of metacognitive strategies that train the learners in self-regulation behaviors (vs. mnemonic strategies) and have reported more robust transfer from strategy training to improvement in functional tasks in children with ADHD and social and emotional behavior disorders (Meltzer, 2011; Mooney, Ryan, Uhing, Reid, & Epstein, 2005; Reid, Trout, & Schartz, 2005). There are limited studies, however, specifically examining the efficacy of strategy training in students with acquired brain injury (Kennedy et al., 2008).

The literature evaluating studies implementing domain-general training is somewhat equivocal. Melby-Lervåg and Hulme (2013) reviewed WM training studies and concluded that they show limited generalization of improvement to untrained tasks, whereas Morrison and Chein (2012) suggested that domain-general training can result in improvement of general cognitive functioning. Studies such as Holmes et al. (2009) and Schmiedek et al. (2010) are examples of studies with positive findings and illustration of far transfer. Epstein and Tsal (2010) reviewed the pediatric cognitive training literature and drew similar conclusions to those of Morrison and Chein (2012). They suggested, however, that the domain-general training is not efficacious for changing school behavior. While there are some positive findings, all of the reviews discuss the multitude of challenges in trying to analyze the literature, including the difficulty of defining what the domain-general programs are actually targeting given the varied types of stimulation, the limitations imposed by effort and expectancy effects, the lack of consistency in methodology, and the confounds produced because of shared components between the training and assessment tasks (Bryck & Fisher, 2012; Epstein & Tsal, 2010; Morrison & Chein, 2012).

The corresponding review in the tandem issue by XX highlights the difficulty in interpreting the current evidence and largely supports the previously mentioned reviews. These authors conducted a systematic review of research studies evaluating a broad range of neurocognitive interventions, including both domain-specific interventions focusing on strategies and behavior, and domain-general interventions focused on improving different aspects of cognitive processing. The participant populations were also variable and included participants with acquired brain injury (traumatic and disease), as well as developmental conditions. In their meta-analysis of the 13 experimentally controlled studies that met their selection criteria, they found evidence of a positive effect of neurocognitive interventions across a broad range of domains, with greater effects for specific cognitive tasks than rating scales or academic performance. However, they found the overall quality of evidence to be low and cited such issues as risk of bias and inconsistency of outcome measures. Given the grouping of interventions with very different theoretical rationale and participants whose conditions have widely divergent etiologies, it is difficult to derive specific clinical guidelines and directions.

There are some similar themes across the studies that identified positive findings and encourage continued exploration of domain-general cognitive training. With respect to domain-general training, the key processes that are targeted in training programs include the following: updating representations in WM, cognitive flexibility and inhibiting competing, and prepotent responses (Bryck & Fisher, 2012). Furthermore, adaptive training that challenges the participants above their current functioning is utilized. The theoretical rationale across different domain-general training programs is also similar and based in models of neuroplasticity. The use of repeated drills assumes that repetitive activation of specific neural networks underlying attention, WM, and EF will strengthen the corresponding neural substrates. Klingberg (2010) describes the neural mechanisms involved in WM training and notes that the synaptic connections determining WM capacity are governed by the same laws of plasticity that characterize other parts of the brain. With respect to the domain-specific training, training behaviors that encourage self regulation of

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learning has clear support (Kennedy et al., 2008).

Research Evidence in Acquired Pediatric Brain Injury

Several studies have investigated the efficacy of combined domain general attention training and domain specific metacognitive strategy instruction to treat pediatric clients with attention deficits because of acquired brain injury. Galbiati and colleagues (2009) completed a study on 65 participants (with 25 as nontreated controls) with TBI, ages 6–18 years, utilizing a computerized attention intervention (*Rehacom* [Schuhfried, 1996] and *Attenzione e Concentrazione* [Di Nuovo, 1992]). Participants also received metacognitive strategy instruction, which the researchers hypothesized would improve participants' awareness of attention (i.e., *meta-attention*) and cognitive control. After the 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 with controls. In addition, 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 posttesting and at the 1-year follow-up, compared with 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 twenty 2-hr weekly sessions, over 4 to 5 months, which combined attention exercises 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 posttask activities, while the cognitive–behavioral aspect of CRP targeted children's ability to withstand distraction via self-talk. Children in the CRP condition 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 with their pretreatment ratings. However, compared with the waitlisted control group, the children in the CRP group did not demonstrate improvement on neuropsychological functioning, including WM and vigilance. Luton and colleagues (2011) evaluated an abbreviated version of Butler and colleagues' (2008) CRP on eighteen 6- to 15-year-old children with a range of neurological conditions, including both developmental conditions and acquired brain injuries with resulting in attentional problems. Their objective was to determine the effectiveness of a shorter version of the established CRP. Participants received six 1-hr CRP sessions, twice a week, over a 3-week period, compared with 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. The abbreviated CRP was associated with significant improvements on impairment-based measures of selective, alternating, and divided attention skills from pre- to posttreatment. In addition, parents reported improvements from pre- to posttreatment on the *Attention Questionnaire* (Sohlberg et al., 1999), which reflects the frequency with which attention problems occur. They did not, however, compare treated children to a control group, and thus it was not possible to distinguish treatment and practice effects.

Van't Hooft and colleagues (2007) also examined the impact of attention drills and strategy instruction on children (ages 9–17 years) with acquired brain injury, including TBIs and nontraumatic brain injuries. 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 min, 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. Participants in the treatment group demonstrated significant improvement in sustained and selective attention, as well as verbal WM on a battery of standardized assessments at posttest, as well as 6 months' posttreatment, when compared with control students.

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However, there were no differences in performance on reaction time (RT) tests between the students in the treatment and control groups. Sjö, Spellerberg, Weidner, and Kihlgren (2010) evaluated the use of the Amat-c with seven children where it was implemented in a school setting and reported positive findings with respect to the feasibility and efficacy of delivering this therapy within the normal school context. In summary, all five of the existing efficacy studies evaluating attention training and metacognitive strategy training with students with acquired brain injury provide initial support for integrating both approaches when working with students. However, in spite of implementing manualized interventions, the treatments are not readily replicable because there are a number of clinical implementation factors that are not identified. The current study explores the clinical factors critical to task and strategy selection and therapeutic interaction when evaluating the use of domain-specific and domain-general therapies with students who have acquired brain injuries.

The goal of this article is to describe an intervention, Attention Improvement Management (AIM), for addressing impairments in attention, EF, and WM in the pediatric TBI population. We report preliminary findings of the AIM program with 11 participants. We were particularly interested in exploring the therapy components that appear to be critical to achieving meaningful improvements in attention, WM, and EF using this comprehensive approach incorporating strategy training (domain-specific training) and repetitive drill practice (domain-general training). Specifically, we identified clinical implementation questions that need to be addressed when employing this type of therapy. We offer an analysis of the clinical decisions and behaviors required by clinicians implementing even a highly proceduralized computer intervention, such as AIM, in hopes of guiding current practice and improving future research investigations.

Method

Participants

This report includes data from participants from a pilot study conducted in Ohio ($n = 7$) and participants seen at the outpatient cognitive rehabilitation training clinic at the University of Oregon ($n = 4$). Eligibility for the pilot study, included the following: (a) history of hospitalization for complicated mild to severe TBI after age 5, (b) current age between 10 and 18, (c) time since injury >12 months, and (d) evidence of current attention problems as defined by a frequency score of 2 or 3 on at least four of nine items from the Vanderbilt ADHD Diagnostic Parent Rating Scale, Attention Subscale (Wolraich et al., 2003). Children with nonblunt injuries, inflicted TBI, or a history of ADHD prior to their injury were excluded. Participants at the Oregon clinic included youth ages 11 to 18 who were seeking treatment for attention problems and postconcussive symptoms following mild TBI/concussion. All clients who sought treatment at the clinic who met the following criteria were invited to participate in the study: (a) received a blow to the head that resulted in altered consciousness or significant confusion, (b) reduced performance on the IMPACT Test persisting more than 3 months' postinjury as reported by sports medicine physician, (3) ongoing modification of school schedule to accommodate cognitive and somatic symptoms, and (4) no previous reported learning disability or mental health condition.

A total of 14 participants were enrolled in the Ohio pilot study, and seven completed the intervention as well as follow-up assessments. Of the seven participants who dropped out, two completed no intervention sessions and three completed a single intervention session with the other two dropping out after two and four sessions, respectively. The reasons cited for discontinuation included health or family factors (two participants), too time-consuming (two participants), or dissatisfaction with the program or clinician (three participants). Participants who completed the program ranged in age between 13 and 16 years ($M = 14.5$; $SD = 1$). Of the seven participants from Ohio, four were labeled complicated mild/moderate severity, and three had severe brain injury. All four youth from the Oregon had mild TBI. Oregon participants constituted a clinical convenience sample because they were referred by local clinic, so it is not known how many participants were referred, but did not choose to

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partake in the intervention. See Table 1 for a summary of participants.

Outcome Measures

The following standardized measures were administered pre- and posttreatment to assess changes in attention, WM, and EF skills. Each of these measures has substantial evidence documenting the reliability and validity for this population and is regularly used in these types of studies.

The Behavior Rating Inventory of Executive Function (BRIEF). The BRIEF (Gioia et al., 2000) is a well-validated, self- and parent/teacher- measure of daily behaviors associated with EF that are often affected following TBI. The Global Executive Composite (GEC) of the parent and adolescent self-report versions of the BRIEF served as a summary measure of problems with behavior regulation and metacognition. The BRIEF also assesses EF abilities across eight clinical scales (Inhibition, Shift, Emotional Control, Plan/Organize, Organization of Materials, Monitor), thereby providing information regarding patterns of improvement.

The Test of Everyday Attention for Children (TEA-Ch). Subtests from the TEA-Ch (Manly et al., 2001) were administered to assess aspects of WM and attention. Specifically, the Code Transmission task provided a measure of WM and sustained attention, the Walk/Don't Walk task provided a measure of inhibition, the Sky Search task provided a measure of selective/focused attention, and the Score! task provided a measure of sustained attention.

Delis–Kaplan Executive Function System (D-KEFS). Specific subtests from the D-KEFS (Delis, Kaplan, & Kramer, 2001) were administered to assess EFs such as flexibility of thinking, inhibition, problem solving, planning, impulse control, concept formation, abstract thinking, and creativity in both verbal and spatial modalities. The Trail Making (flexibility of thinking on a motor task), Color-word Interference (verbal inhibition), and Tower (planning and reasoning, impulsivity) subtests were administered to assess improvements on laboratory measures of inhibition and EF.

AIM program gathered data. Because the program is computer delivered, it gathers a range of data related to the frequency of practice across a week, the types of attention, and WM tasks utilized (sustained, selective, WM, suppression, or alternating attention tasks), types of strategies (see Table 2) and task accuracy. During the weekly clinic visit, the clinician also recorded reasons for modifying tasks or strategies (e.g., criteria met, too difficult; participant appeared bored, limited progress; set off somatic symptoms) and hypothesized reasons for lack of compliance or engagement (e.g., seemed bored, lacked self confidence, technology issues, family stressors, or competing activities).

Goal Attainment Scale (GAS). AIM uses an automated process to structure Goal Attain-

Table 1
Demographics

Age (years)	Gender	Race	Etiology	Time since injury (months)	Severity
Ohio Participants					
15	M	AA	Pedestrian collision with vehicle	54	Complicated mild
15	F	W	Pedestrian collision with vehicle	49	Severe
14	F	W	Recreational	43	Moderate
15	F	W	Recreational	69	Complicated mild
13	F	W	Fall	99	Severe
13	F	W	Recreational	92	Severe
13	F	W	Motor vehicle accident	43	Complicated mild
Oregon Participants					
16	M	W	Recreational	5	Complicated mild
16	M	W	Recreational	9	Complicated mild
15	F	W	Recreational	8	Complicated mild
15	F	W	Recreational	6	Complicated mild

Note. M = male; F = female; AA = African American; W = White.

Table 2
Personalized Metacognitive Strategies Selected by Participants

Strategy type	Personal wording appearing on Attention Improvement Management (AIM) interface
Mental imagery	Imagine myself done with the task and being able to do something fun
Internal self talk	Periodically during the task, say in my head: "Wait, don't do it"
	When I start to space out, I will say "Stay focused Kim and keep eye on the prize!"
	When my attention starts to fade, I will tell myself, "Pay attention Henry!"
	When my attention starts to go away, tell myself: "Keep on"
	I will block out other sounds and remind myself by saying: "focus"
	"Refresh"
	Tell myself my motivation words, "I can do it"
Repeat or clarifying instructions	Say back what you are supposed to do in this task
	Say the directions in my own words!
External self talk	Say out loud what I'm doing while I'm doing it
	Tell myself out loud "just keep going"
Breathing	Take a deep breath with long exhale when my attention fades
Goal setting	Check off each task as I finish
	Put my session prize on the table where I can see it

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ment Scaling, a criterion-referenced measure of a person's goal achievement using a collaborative interview process involving the clinician, participant and parent. GAS (Malec, 1999) quantifies summary outcomes across participants receiving the same intervention, but who have different individual goals (Ottenbacher & Cusick, 1990; Trombly, Radomski, Trexel, & Burnett-Smith, 2002). For direct cognitive interventions, GAS provides an ecological measure of generalization to activities that are meaningful to participants and their families. Consistent with previous research, goal attainment was rated on a 5-point scale (−2 to +2). The midpoint of 0 was established as the predicted expected level of performance, with −1 and +1 indicating somewhat less than and somewhat greater than expected performance, respectively.

AIM

Program description. AIM is a 10-week, computerized treatment program that incorporates goal setting, the use of metacognitive strategies, and computer-based exercises designed to improve various aspects of attention and WM. The attention drills were modeled after the adult cognitive rehabilitation program Attention Process Training (APT; Lash & Associates, 2010). The metacognitive strategy options were generated from a systematic review of the pediatric strategy training literature. The interface and computerized training components were modeled after elements from previous assistive technology for cognition tools generated from an interdisciplinary lab at the University of Oregon with software engineers and cognitive rehabilitation researchers led by the first author. The goal in developing this intervention was to create a hybrid approach marrying attention training and metacognition/strategy content supported by existing studies in a manualized approach that could be delivered by a range of educational or health care professionals working with the pediatric TBI population. The present pilot study is the first formal evaluation of the AIM program.

In delivering AIM, after the initial intake session, described below, each subsequent session consists of the following components: (a) a review of home-based practice and use of metacognitive strategies, (b) in-session completion of the 5–6 assigned attention training tasks while the clinician is observing, and (c) review of homework for the upcoming week. During the intervention, participants were expected to complete 2–4 practice sessions per week, and treatment was extended by 1 week for each week that the child failed to complete at least two home practices such that the total number of sessions varied as a function of patient adherence. The rationale for this extension was to increase intensity when a participant's adherence was compromised and to ensure a compa-

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rable number of practice sessions across participants.

During the initial meeting with the child, the computer program leads the clinician through an intake procedure that assists in identifying the nature and severity of the child's attention difficulties and then facilitates the selection of attention training tasks and metacognitive strategies tailored to the needs of the child. Based on the clinician's ratings, an initial, computer-generated program of drills and strategies is proposed. The role of clinician is to select the specific, presenting cognitive areas that are impaired, as well as to modify the tasks and strategies in response to improvements over time.

AIM has a built-in home practice component using a USB drive that synchs with the AIM program after each session. The drive has the capacity to record and electronically send participant practice performance collected at home to the clinician's computer for review. Participants were instructed to complete the assigned attention drills 2–4 times per week, which typically consisted of six tasks each 3 min in duration. Participants received incentives for completing home practices (brain points that were tied to monetary rewards). The target range of practice sessions was based on the ranges for intensity of practice reported in the literature. AIM incorporates frequent home practice, to boost treatment intensity, one of the tenets of domain general training. Having the ability to practice at home decreased the need to have multiple face-to-face therapy sessions per week, which is often not feasible because of barriers including limited third-party reimbursement and unreliable transportation. The emphasis on independent home practice circumvented these clinical delivery constraints.

Attention exercises. The attention exercises in the AIM program consist of hierarchically organized drills categorized by the attentional domains they target. The attention components are divided into two main types: basic sustained attention and attention requiring executive control, which includes selective attention, WM, suppression, and alternating attention (Sohlberg & Mateer, 2010). These domains correspond to the WM and EF domains described in the literature review of cognitive retraining in the developmental pediatric population in the introduction. See Appendix A for a description of the AIM tasks organized by attention domains.

Strategy training. Metacognitive strategy training is integrated with the attention drills in two ways. First, participants receive instruction in using selected strategies that increase attention and engagement such as reauditorization, self-talk, breathing, and using an agenda to track progression through tasks. Instruction consists of initial modeling and practice with the clinician. The AIM program generates individualized strategies from a list of options for each student based on responses to the computerized intake process. Clinicians can tailor strategies to build upon existing student strengths and incorporate individualized wording. Second, the program seeks to develop the metacognitive skill of self-monitoring by prompting students to self-reflect on motivation and performance after each exercise allowing the clinician to explore their influence on the child's performance. See Appendix B for an overview of one of the participants' AIM program.

While similar to other described interventions for ABI, unique elements of AIM include the following:(a) the ability to individualize and personalize the strategies, (b) active facilitation for learning and practicing strategies, (c) building self-awareness through regular self-rating of effort and motivation, and (d) self-evaluating by reviewing current and prior performance data presented by the computer. Other interventions provided more informal reflection and self-monitoring at a more global level.

Study clinicians. Clinicians were trained during a 2-day, face-to-face training conducted by the first author. All clinicians had at least 1 year experience working with individuals with TBI and was primarily delivered by graduate students ($n = 4$), one undergraduate, and a senior psychologist. To ensure consistency across clinicians, weekly phone meetings occurred to discuss participants' performance, progress, as well as intervention modifications and calls led by the first two authors.

Results

Treatment dosage for students who completed the study varied; the number of in-clinic sessions ranged from eight to 12 (more sessions were added for participants who had not completed at least two home practice sessions), and

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the number of self-initiated 20- to 40-min home practice sessions ranged from 15–41 ($M = 2.5$ per week).

One of the central, and unanticipated, findings of our pilot study was that in spite of having a highly manualized program, there were a myriad of clinical behaviors and decisions required of the clinicians beyond monitoring client completion of the program. A review of the session and outcome data identified three arenas that required clinical judgment: (a) clinical treatment decisions, (b) promoting and maintaining participant engagement, and (c) clinical interpretation of outcomes. A discussion of each of these follows.

Clinical Treatment Decisions

Our analysis suggested three different types of treatment decisions were heavily influenced by clinician judgment and had the potential to be highly variable: task selection, strategy selection, and selection of outcome goals.

Task selection. The AIM program uses a clinical decision algorithm that determines the initial selection of specific attention tasks based on the rating of attention domains on the intake survey. Ratings are gleaned from a combination of scores on assessments, observation and clinical interview. Ongoing modification and selection of attention tasks over the course of the treatment is based on the accuracy of performance on tasks within each attention domain. These automated parameters can be overridden by the clinician who records the rationale for modification. A review of both the selection of initial attention tasks and the subsequent modification of attention tasks during pilot participants' treatment programs revealed a disconnect between the child's performance on the neuropsychological test battery and the type of attention tasks that were selected. Tasks targeting sustained, selective, and alternating attention as well as WM were selected by the program based on the intake survey. However, in most cases, it was not the standardized measures that determined the attention ratings. Instead, parent and student feedback from a clinical interview and ratings on the BRIEF (Gioia et al., 2002), as well as clinician observation, were primarily used to identify attention difficulties and select AIM tasks. For some participants, the standardized measures were in the average range so the BRIEF was more useful. Low correlations between neuropsychological tests and behavior rating assessment methods in addition to limited ecological validity of standardized neuropsychological tests has been well documented (e.g., Barkley, 2012).

Clinical decision making was also essential to modifying the difficulty of the tasks over time (i.e., faster vs. slower). The participant's program was modified when the clinician observed a performance characteristic that she deemed worthy of addressing. For example, one participant had met the 90% accuracy criteria for three times in a row on a task (criterion for moving to a more difficult task), but the participant demonstrated low self-efficacy and appeared to be working hard to achieve that score. In this situation, the clinician opted to ignore the decision rule to maximize motivation and reinforce progress. The most common reason for modifying the tasks was because the participants met criteria, but clinical judgment was frequently used to override the program to maximize participant engagement (i.e., report of boring task or frustration).

Strategy selection. Unlike the selection of attention tasks, the AIM program uses a clinical decision algorithm that provides a closed set of options for different cognitive strategies rather than identifying a specific strategy. The selection of metacognitive strategies is completely determined through clinical judgment from interviews and observation. A review of our pilot data suggested that out of 11 strategy domains offered by the AIM program, seven different strategy types were selected with *internal self talk* being the most commonly selected. The program allows clinicians and participants to collaboratively generate or personalize strategy wording or they can use pre-established wording. In every case, individualized wording was selected. These data suggest that clinicians and participants perceived individualized selection and delineation of strategies as clinically worthwhile. See Table 2 for list of strategies selected by the students.

The rationale for changing strategies varied with the most common reason being that a strategy was mastered and no longer needed so that new or additional strategies could be added. This was based on clinician observation of the client and client report.

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Selection of outcome goals. A list of the different GAS areas generated with our pilot participants is available in Table 3. Among this population, the most common arena selected for goal attainment was schoolwork completion. AIM provides the templates, but by definition, this outcome measure requires collaborative interview, thus is heavily reliant on the input from the student and skills of the clinician. Across the 11 participants, five reported improvement beyond expected progress, three reported expected progress, two reported less than expected progress, and one did not complete the GAS.

In summary, a number of components of the AIM program require clinical decision making beyond what could be automated in a computer program. Even the selection of the attention drills required clinical decision making independent of the algorithms. Therapies that use strategies and individualized goal attainment, by definition, will require observation, collaboration, and ongoing clinical guidance.

Promoting and Maintaining Engagement

Establishing therapeutic alliance and methods for facilitating participants' ongoing engagement is not discussed in most of the research evaluating pediatric cognitive retraining, yet our experience suggest this is a critical domain, for both domain-general and domain-specific training. Treatments that are based on activating specific neural circuitry necessarily require sufficient effortful processing. Similarly, implementation of self-initiated cognitive strategies inevitably demands adequate motivation and engagement. This led us to monitor two issues potentially illustrative of motivation and engagement: home practice adherence and clinical management beyond the delivery of basic verbal reinforcement (e.g., "good job" when participant completed an exercise or used a strategy).

Part of the AIM protocol is to check in with the participant each session and review their home practice experience. The five reasons reported for not doing home practice, including frequency of report, were as follows: technical issues (8), forgot (5), not enough time (5), somatic issues (4), and not motivated (3). When home practice was not completed, the clinician helped problem-solve with the participant to remove the barrier(s), which was successful in most cases. Again, this is a critical arena that required clinician support.

Session notes indicated that the two most common situations that prompted the clinician to intervene and address motivation and engagement were (a) when cognitive effort waned in a session and (b) when frustration with low performance resulted in discouragement. For the first case, clinicians described a number of clinical behaviors including prompting, redirection, and generating sports analogies for how exercise and practice improves performance. For the second scenario, clinicians reduced task complexity and increased verbal reinforcement and reassurance. Ultimately, our research team developed a matrix of specific clinical responses for different types of perceived motivational challenges to foster maximal effort given that the effectiveness of the intervention was closely tied to patient engagement and motivation (see Table 4).

Table 3
Goal Attainment Scale (GAS) Outcomes Posttreatment

Selected goal area	Final GAS rating
Improve sustained attention in order to increase productivity when doing science and math homework	−1
Decrease impulsive interrupting/arguing with teachers	1
Stay on task for longer and decrease amount of mind wandering (2 participants)	1, 0
Increase homework productivity (2 participants)	2; 0
Less distractibility during homework (2 participants)	1; 1
Be able to read for longer period of time	−1
Decrease amount of "bugging" from mom	0

Note. GAS Rating (Malec, 1999). +2 = best expected outcome; +1 = more than expected outcome; 0 = expected outcome; −1 = less than expected outcome (baseline level/no change); −2 = worse than expected outcome. One participant did not complete a GAS rating.

Clinical Interpretation of Outcome

Similar to the reviewed interventions, this pilot study measured treatment outcomes using a combination of neuropsychological tests (D-KEFS, TEA-Ch), parent- and child-report questionnaires of EF behaviors (BRIEF), and

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Table 4
Clinician Guide for Increasing Motivation and Engagement

Motivational challenges	Possible sources of problem	Clinician responses
Participant seems bored	Tasks are too easy	Increase difficulty of tasks
	Computer program is uninteresting to client	Affirm that the tasks can be boring and link back to goal that is meaningful. Explore reinforcers tied to brain points
	Does not like having structured "school like" activity	Increase level of connection with student. Use humor, ask about interests, work to make interaction before and after session fun. Explore reinforcers tied to brain points
Participant does see value of program	Does not understand how program works	Use sports metaphor to explain drills
	Does not believe program will work	Provide testimony and examples from others who have participated in the program.
	Does feel like exercises are "worth it"	Revisit Goal Attainment Scaling if current goals are no longer meaningful. Use motivational interviewing

cognitive functioning in naturalistic contexts (GAS). The most consistent trend was the highly variable performance on neuropsychological tests both in terms of pretest and posttest performance. The hugely variable pretest scores document the heterogeneity of pretreatment attention functioning within this TBI sample. Posttest outcomes ranged from no change, negative change, positive change and substantial change beyond what would be expected. Table 5 reports pre- and posttest performance on standardized subtests and demonstrates the variability in performance and response.

Subtests that demonstrated more than a 3 standard score improvement at posttesting are bolded and highlighted, and the final row of the table notes the number of subtests that each participant demonstrated substantial improvement on at posttesting. As noted in the table, only participant #2 showed improvement across all subtests with three others (#1,

Table 5
Selected Pre- and Posttreatment Subtest Results From the D-KEFS and TEA-Ch Measures

	D-KEFS subtests												TEA-Ch subtests							
	Number S		Letter S		N-L Switch		Comb		Inh/ Switch		Tot Ach		Sky Search		Score		Walk DW		Code T	
Subj	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
01	3	**11**	6	8	1	**7**	4	**10**	1	**12**	10	**13**	—	—	—	—	—	—	—	—
02	3	**8**	1	**7**	3	**6**	1	**8**	7	**11**	11	**15**	—	—	—	—	—	—	—	—
03	9	7	8	10	6	7	9	9	12	12	8	**13**	7	8	3	**6**	7	8	5	**10**
04	12	13	12	13	13	14	13	14	12	**15**	13	10	11	13	11	7	11	**15**	12	12
05	2	**9**	1	**9**	6	**10**	1	**9**	12	11	5	7	8	3	8	7	3	3	8	8
06	1	1	1	1	1	1	1	1	1	1	11	5	1	1	4	1	—	2	1	1
07	10	11	12	11	11	11	12	12	7	**12**	11	12	8	**12**	12	12	13	11	10	9
08	1	1	1	1	3	1	1	1	5	5	9	**12**	1	2	11	5	5	1	4	**10**
09	3	**11**	2	**9**	9	6	2	**10**	6	6	12	11	6	**9**	5	7	1	**8**	3	**9**
10	12	10	10	11	10	9	12	11	10	8	12	12	10	11	7	5	6	**13**	9	**12**
11	10	10	9	11	10	9	10	11	7	**11**	13	**19**	3	**15**	6	**13**	9	**14**	1	**13**
SI		4		2		2		4		5		5		3		2		4		5

Note. D-KEFS = Delis–Kaplan Executive Function System; TEA-Ch = Test of Everyday Attentio for Children. Improvements > 3 SS points at posttesting are in boldface. Number S = Number Sequence; Letter S = Letter Sequence; N-L Switch = Number-Letter Switching; Comb = Combined Sequencing; Inh/Switch = Inhibition/Switching; Tot Ach = Total Achievement; Walk DW = Walk/Don't Walk; Code T = Code Transmission; Subj = Subject Number; SI = Number of participants that showed significant improvement at post-test. — indicates assessment data was not obtained.

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#9, #11) showing improvement in more than half of the measures and the remaining six showing improvement on less than four measures. While there were no measures that all participants improved their performance, there were three measures on which at least four participants improved that were related to WM (i.e., number sequencing and combined sequencing), as well as alternating attention (i.e., inhibition/switching) from the D-KEFS. The data also indicated that five of the 11 participants (i.e., #3, #4, #7, #10, and #11) had pretest performance in the broad average range across almost all measures leaving limited room for improvement.

Examination of these data led to three hypotheses: (1) the well-documented variable performance in this population makes static neuropsychological testing an unreliable measure of progress over short periods of time (i.e., 10–12 weeks), (2) the neuropsychological tests do not tap the processes suggested in their validity studies, or (3) the AIM treatment is of insufficient duration and/or intensity or is not efficacious to result in improved neuropsychological outcomes. The developmental pediatric literature evaluating the efficacy of cognitive retraining discusses the difficulties with attempting to measure possible effects of retraining, particularly in selecting tasks that represent the same cognitive domain that was trained but are not so similar that they do not allow the evaluation of transfer (Klingberg, 2010).

While the neuropsychological tests were variable and did not reveal consistent findings, the parent- and self-report versions of the BRIEF (Gioia et al., 2002) questionnaire provided a somewhat more consistent indicator of improvement. Of the 10 parents who completed the BRIEF questionnaire before and after their child's treatment, six of them rated significant improvements on scales related to Inhibition and Shifting which were two areas that were heavily targeted as part of the AIM program (Table 6, bolded items demonstrate significant improvement). In addition, 3 of 10 participants showed substantial improvement across more than half of the subtests and domains. Considering this small data set and descriptive nature of this pilot study, it is premature to make statements about the sensitivity and utility of this measure. However, the use of the BRIEF as a helpful outcome measure of pediatric cognitive retraining is supported in developmental literature (e.g., Beck, Hanson, Puffenberger, Benninger, & Benninger, 2010).

The GAS was the most consistent and positive indicator of change. As shown in Table 3, eight of 10 participants who completed the GAS reported improvement on his or her self-generated generalization goal at least one level above baseline. It is these findings that most motivate future efforts to further evaluate the efficacy of this intervention. Of note, there was no indication of a pattern across any of the outcome measures that the amount of

Table 6
Pre- and Posttreatment Results From the Behavior Rating Inventory of Executive Function (BRIEF) Parent Report

BRIEF Domain	Participant T-Scores Pre- and Posttreatment																			
	01		03		04		05		06		07		08		09		10		11	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
EC	60	**48**	40	40	70	68	77	72	63	**47**	59	**47**	59	**42**	47	56	71	**54**	54	63
BRI	53	47	38	38	68	68	81	**65**	58	50	68	**49**	63	**46**	63	58	72	**57**	58	60
WM	87	**71**	53	48	82	84	79	79	82	77	82	**64**	72	**58**	82	77	77	69	69	**58**
MI	71	67	79	80	45	41	69	66	77	**67**	73	**61**	71	63	79	79	84	**73**	63	60
GEC	67	62	42	39	76	76	76	67	70	61	71	**56**	69	**57**	75	73	82	**68**	61	60
SI		2		0		0		1		2		5		3		0		3		1

Note. EC = emotional control; BRI = Behavioral Regulation Index; WM = working memory; MI = Meta-Cognitive Index; GEC = Global Executive Composite; SI = number of BRIEF domains with significant improvement at posttest for each participant. Posttreatment improvements >10 T-score points are in boldface; T-scores have a mean of 50 and *SEM* of 10; higher scores indicate more significant concern. BRIEF Parent Report data was not obtained for Participant 02.

practice was associated with more or less gains.

Discussion

The results of this study are consistent with previous intervention studies suggesting that broad based training that includes both domain-general and domain specific approaches holds promise as an intervention to remediate attention, WM and EF deficits in the pediatric acquired brain injury population. However, there are critical components of this therapy that are influenced by clinical heuristics that have yet to be operationalized. Algorithms to assist delivery of computerized cognitive treatment can be smart and adaptive (Klingberg, 2008; Morrison & Chein, 2012), but if a program is individualized and dynamic (characteristics the authors believe are necessary when delivering direct cognitive interventions), there are human factors that cannot currently be automated.

Task and strategy selection and clinician facilitation of effort and engagement represent key clinical components that were dependent on clinician judgment. While the program was developed to minimize the need for a highly trained clinician, there are certain factors that the computer is unable to measure and to modify based on its assessment, but that can be straightforward to address if a clinician is watching. For example, if the participant was either not listening to or was confused by the directions that were presented before the task, the clinician was able to observe the participant's confused look and either reengage the participant or replay the directions. Related to strategy use, clinicians are able to check in with the participants to determine if the strategy is still useful (e.g., assess ability to independently use the strategy during intervention as well as inquire about use in a classroom/social setting) or discern whether another strategy may be better suited to meet the student's needs and maintain motivation. These clinician behaviors were largely intuitive, and required some face-to-face interaction. The pilot study suggests that this type of intervention will require some direct observation built into the therapy protocol in order to adjust tasks and strategies.

It is important to identify key clinical intervention components for several reasons. The field needs to be able to implement the cognitive training with high levels of treatment fidelity to identify the active treatment components in efficacy studies (Harn, Parisi, & Stoolmiller, 2013). Like the current study, all of the pediatric brain injury studies reviewed used manualized, and in several cases, computerized interventions, yet the requisite ingredients for the therapy are not known as there are many clinical factors related to task and strategy selection that are unclear. Without clear delineation of the active treatment components, it will not be possible to conduct research that allows us to identify the underlying mechanisms responsible for change. Furthermore, little is known about candidacy issues, including age, time since injury, and severity of injury. For example, improvement is expected for some injuries (e.g., concussion) without intervention thus time since injury may be a critical consideration. Age may be another critical participant characteristic. In the developmental literature, it has been suggested that computerized retraining for EF might be more beneficial for children between the ages of 8–12 than for those who are younger (Diamond & Lee, 2011). Given that heterogeneity is a hallmark characteristic of brain injury, responsivity to treatment will certainly vary according to individual profiles; without a clear description of the therapy components, we cannot begin to discern what types of participants are best helped by the program.

Beyond the need to identify effective cognitive interventions for pediatric brain injury, there has been a proliferation of computerized "brain programs" for clients with learning challenges from a host of developmental and acquired etiologies (e.g., Rabipour & Rax, 2012). The field demands that we can validly evaluate the contribution of different treatment components.

Study Limitations

The results of this pilot study mirrored the cautious optimism from prior research efforts that the direct training of attention, WM, and EF combined with strategy instruction may improve cognitive functioning in some children with TBI and warrants further investigation. The study also shared a number of limitations identified in the literature. Specifically, the data are based on a small, heterogeneous sample with highly variable

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exposure to treatment which limits the conclusions that can be drawn. In addition, we did not have a control group in our pilot efforts. The pediatric TBI population presents particular research challenges because of the variability inherent in such factors as nature of injury, age of injury, and a host of premorbid factors all of which make it difficult to form control groups. Variability was further introduced in this particular study by having a wide range of therapist background and training. Close supervision and monitoring of all interventions to ensure consistency mitigated this potential issue.

As with most intervention research with the pediatric TBI population, determining how to evaluate the efficacy of the intervention was a challenge. Use of repeated measures raises questions about whether change in scores was because of practice effects or possible regression to the mean. The variability in how some participants performed on the outcome measures as well as the limited agreement between neuropsychological measures and parental ratings, especially at pretest, makes interpretation of findings a challenge.

There is a need to standardize intervention techniques and study the relationship between critical factors such as the amount of exposure to treatment and outcome. Similarly, examining participant profiles (e.g., severity and premorbid functioning) and treatment responsivity would provide needed information on candidacy. To implement this research, however, it will be important to first identify outcome measures that are sensitive and ecologically valid.

Conclusion

Examination of the descriptive data from our pilot investigation of the AIM intervention suggests three arenas that introduce clinical judgment and require further standardization: (a) clinical treatment decisions around task and strategy selection and generalization targets, (b) methods to promote and maintain participant engagement, and (c) clinical interpretation of outcome data. Continued exploration of these clinical implementation domains with the goal of operationalizing our clinical decisions is important for both future research and improved clinical practice.

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Appendix A

AIM Task Names by Attention Domain

Basic Sustained (Tasks Targeting the Ability to Maintain Attention During Continuous Activity)

Listening for 1 (number, letter, noise, animal)
Listening for 2 (number, letter, noise, animal)
Listening for 2 numbers (ascending/descending)
Matching digital and analog clocks
Watching for multiples of 3 (easy #1–30; hard #1–99)
Watching for number comparisons (easy/hard)
Matching (clock times, season and month words, faces and emotion words)

Selective Attention With Either Noise or Visual Distractors (Tasks Targeting Ability to Screen Out Nontarget Information)

Listening for 1 number
Listening for 1 letter in a word
Listening for 1 noise
Listening for 1 animal sound
Listening for 2 numbers
Listening for 2 letters in a word
Listening for 2 noises
Listening for 2 animal sounds
Listening for 2 numbers ascending
Listening for 2 numbers descending
Matching digital and analog clocks
Watching for multiples of 3 (easy #1–30)
Watching for multiples of 3 hard #1–99)
Watching for number comparisons (easy)
Watching for number comparisons (hard)
Matching clock times
Matching season and month words
Matching faces and emotion word

Working Memory (Tasks Targeting the Ability to Temporarily Hold Onto and Manipulate Incoming Information)

Matching 2-back (abstract shapes, animals, clock times)
Serial number calculations (2-step, 3-step)
Number sequences (ascending, descending, reverse)
Number sequences (add 3, subtract 2)
Word sentences (alphabetical, progressive, reverse)

Suppression (Tasks Targeting the Ability to Control Impulsive Responding)

Auditory switching (happy-sad, high-low, loud-soft, child-adult, slow-fast speech, falling-rising, serious-silly)
Visual position (above-below, left-right, high-mid-low, left-right-center, north-south-east-west, left-right-top-bottom, up-down-forward-backward-diagonal)
Visual stimuli (big-small word, solid-hollow letters, numbers-digits, circle-triangle-square)

Alternating With Periodic "Switch" Direction (Tasks Targeting the Ability to Shift Focus of Attention)

Happy-sad intonation
Falling-rising intonation
High-low pitch
Loud-soft volume
Child-adult voices
Slow-fast speech rate
One-two voices
Serious-silly intonation
Left-right position
Above-below position
Big-small word size
Solid-hollow letters
Circle-triangle-square in shapes
Circle-triangle-square word shapes
High-mid-low position
Left-right-center position
North-South-East-West position
Left-right-top-bottom position
Up-down-forward-backward-diagonal writing

(*Appendices continue*)

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Appendix B

Case Study of M

Client description. M. was a 15-year-old female in the 9th grade. She sustained a mild TBI from a fall 5 years ago. M. and her mother identified ongoing difficulties in school primarily related to impairments in WM and sustained attention.

AIM program. M. completed 10 weeks of AIM with 10 clinic visits and 21 home practice sessions. Her intervention consisted of the following:

Attention tasks. Attention tasks were selected in the intake process based on testing and a clinical interview. Tasks over the 10 weeks were distributed in the following attention domains: sustained attention (25% of tasks), selective attention (13% of tasks), working memory (48% of tasks), and attentional switching (13% of tasks). Tasks were changed when performance criteria were met and were altered 3 times when tasks were identified as too difficult.

Strategies. Two strategies were selected and practiced over the course of the program: (1) Task clarification (*repeat activity instructions in my own* words) and (2) Internal self-talk (*when my mind starts to wander*, *I will tell myself to focus*). M. became independent in using her strategy after 4 sessions.

Outcomes

I. Neuropsychological Measures

M. performed in the averaged range on most of the neuropsychological subtests at pretest. For the two subtests not in the average range, her score on the Inhibition/Switching subtest of the D-KEFS (alternating) improved from a scaled score of 7 to 12 and on the Sky Search subtest of the TEA-Ch (working memory) she improved from 8 to 12.

II. BRIEF Parent Report and Self-Report

The self-report results showed significant improvement across all subtest and composite scores at posttest. Overall improvements were noted by the parent with significant improvements in emotional control, WM, planning and organization, monitoring, inhibition, initiation, and on the overall Behavioral Regulation Index.

III. Goal Attainment Scaling

Goal was for M. to complete all homework on time for an entire week. At intervention completion, the parent and M. rated the GAS as a +2 (best expected outcome) because she was consistently completing work in class and had less homework, which was also consistently completed on time over the weeks of the intervention. M. also said, “I feel more organized and am using my free time at school to get work done. My grades are better because I am getting credit for my homework.” The mother reported M. is completing homework more quickly and is getting better at ignoring people who are bothering her. She is getting more work done at school so has less to bring home.

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