Attention Remediation Following Traumatic Brain Injury in Childhood and Adolescence

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Traumatic brain injury (TBI) frequently affects both the basic and the superordinate components of attention; deficits vary according to patient age. This study evaluated the efficacy of a specific remediation intervention for attention. Sixty-five TBI patients (aged 6–18 years) with attention deficit were assessed at baseline and at 1-year follow-up: 40 patients received attention-specific neuropsychological training for 6 months, and the control group comprised 25 patients. Cognitive assessment included a Wechsler Intelligence Scale (e.g., A. Orsini, 1993) and the Continuous Performance Test II (CPT II; C. K. Conners, 2000). The Vineland Adaptive Behavior Scales (VABS; S. Sparrow, D. Balla & D. V. Cicchetti, 1984) was administered to assess the treatment’s ecological validity. At baseline, all patients presented with a mild intellectual disability and pathological scores on the CPT II. At follow-up, significant differences were found between the 2 groups on the CPT II and VABS: The clinical group improved more than the control group. Specific remediation training for attention, including a combination of a process-specific approach and metacognitive strategies, significantly improved attention performance. Improvement in attention skills also affected adaptive skills positively.

**Keywords:** traumatic brain injury, attention components, cognitive deficit, neuropsychological treatment, ecological context

The literature frequently reports attention impairments after traumatic brain injury (TBI) that affect both the basic components of attention (vigilance, sustained attention) and the superordinate components of attention control ([selective attention, alternation attention, inhibition, shifting, divided attention] Bate, Mathias, & Crawford, 2001; Parasuraman, Mutter, & Molly, 1991; Sohlberg & Mateer, 1987; Van Zomeren & Brouwer, 1994; Wassenberg, Max, Lindgren, & Schatz, 2004; Yeates et al., 2005). Some studies have also reported problems with inattentive behaviors, such as distractibility and the inability to inhibit responses to irrelevant information, as well as a tendency to overprocess redundant stimuli (Bate et al., 2001; Cicerone, 2002).

The extent and the quality of the attention deficit after a TBI varies according to the patient’s age: In childhood and adolescence, the central nervous system has not yet reached full maturation, as the frontal and temporal regions and attention continue to develop anatomically and functionally until adolescence. A focal lesion in these areas affects the development process and can therefore cause structural and functional changes (Anderson, Damasio, Tranel, & Damasio, 2000; Anderson & Pentland, 1998; Murray, Shum, & McFarland, 1992). Young children with severe TBI are at risk of severe, persisting attention impairments. Children with mild and moderate TBI show a better outcome, with preinjury behavior and age also being predictive of attention skills at 30 months postinjury (Anderson, Catroppa, Morse, Haritiou, & Rosenfeld, 2005).

Many studies in the literature discuss attention deficits and the efficacy of remediation programs for adults with acquired brain injuries (ABIs; Michel & Mateer, 2006), whereas a few studies look specifically at TBI (Eslinger, 2002; Fernandez-Guinea, 2001; Nag & Rao, 1999; Oh, Kim, & Seo, 2005; Sohlberg & Mateer, 2001).

Knowledge of the rehabilitation of attention deficits comes largely from clinical research on adults with acquired attention disorders and from the literature that focuses on children with neurodevelopmental disorders of attention, particularly attention deficit–hyperactivity disorder (ADHD; Mateer, Kerns, & Eso, 1996; Shalev, Tsal, & Mevorach, 2007). Remediation strategies in this area fall into one of four categories: attention process training (APT; Sohlberg & Mateer, 2001), self-management strategies and environmental modifications (Mulligan, 2001; Shapiro, DuPaul, & Bradley-Klug, 1998), external aids to help track and organize information; and psychosocial supports for the emotional and social factors that result from or exacerbate attention difficulties (Michel & Mateer, 2006).

Papers are beginning to emerge that document attempts to address the cognitive sequelae of ABIs and to evaluate the effectiveness of cognitive rehabilitation in children and that outline some common methodological difficulties (Hooft et al., 2005;
ATTENTION TRAINING AND TBI ATTENTION REMEDIATION

Limond & Leeke, 2005; Penkman, 2004); specific research on the effectiveness of cognitive rehabilitation techniques in pediatric patients with attention deficit after TBI remains scarce (Michaud, 1995).

To present the rationale for our remediation program, we specifically explored the methodology of three studies on children and adolescents with primary deficits in attention following an ABI. Two of these investigations use a process-specific approach, APT, with children and adolescents who sustained TBI (Thompson, 1995; Thompson & Kerns, 2000); one of them (the Cognitive Rehabilitation Program) uses APT associated with metacognitive strategies from the field of education, cognitive–behavioral interventions that reduce distractibility and teach children being treated for cancer how to be their own coach for lengthy and difficult activities, as well as how to learn mnemonic strategies (Butler & Copeland, 2002). However, neither study provided any conclusive evidence for the efficacy of cognitive rehabilitation in children with an ABI (Limond & Leeke, 2005).

The literature on this is growing (Hooft et al., 2005, 2007; Hooft, Andersson, Sejersen, Bartfai, & Von Wendt, 2003), and recent studies have used cognitive measures as well as neuroimaging data (Jha, 2002; Klingberg, 2006; Olesen, Macoveanu, Tegner, & Klingberg, 2007; Wozniak et al., 2007).

Another important aspect concerns the ecological validity of the intervention. Like remediation interventions for adults (Carney et al., 1999), the specific nature of individualized programs has resulted in the use of a wide range of outcome measures. Many practitioners agree that the desired outcome of cognitive rehabilitation is an improvement in daily functioning (Spooner & Pachana, 2006; Van Baalen, Odding, Van Woensel, & Roebroeck, 2006). However, many studies used intermediary measures and rely on an improvement in standardized testing to reflect an increase in general ability, but this does not necessarily translate into adaptive functioning (Hooft et al., 2005; Thompson & Kerns, 2000). Conversely, some studies showed improvements in specifically trained tasks, but this only tells us about those particular tasks and not about the generalizability of the intervention (Oberg & Turkustra, 1998; Pavawalla & Schmitter-Edgecombe, 2006). None of the reviewed studies examined the validity of outcome measures that were used. An assessment of adaptive functioning may be considered to have higher ecological validity. Instruments of known reliability and validity, such as the Vineland Adaptive Behavior Scales (VABS; Sparrow, Balla, & Cicchetti, 1984), would improve the replicability of these studies (Limond & Leeke, 2005).

On these assumptions, we set out to investigate the efficacy of a specific type of attention remediation training in children and adolescents with TBI. Our approach to rehabilitation is derived from studying the literature and from our 10 years of clinical experience with this type of patient (Liscio, Galbiati, & Poggi, 2003) and consists of a combination of process-specific training and metacognitive strategies.

In this study, we had the following goals:

(a) to describe the cognitive profile and to assess attention deficits by using the Continuous Performance Test II (CPT II; Conners, 2000) in children and adolescents with TBI (aged 6–18 years);

(b) to evaluate the efficacy of our specific remediation intervention, a combination of the process-specific approach and metacognitive strategies, in comparison with a control group who did not receive our training, or any other type of training, and to verify the persistence of these results at 1-year follow-up from baseline (The proposed training is derived from a reassessment of the models proposed in the literature [Butler & Copeland, 2002; Thompson, 1995; Thompson & Kerns, 2000] and is based on our long clinical experience in the context of the rehabilitation of children and adolescents with serious head injuries);

(c) to verify the ecological validity of the remediation intervention, as well as its generalizability to real-life contexts, by using the VABS; and

(d) to verify the effect of some clinical variables on the subject’s attention performance.

Method

Subjects and Materials

We selected 65 patients from a pool of 173 posttraumatic patients, who were hospitalized in our intensive rehabilitation unit and who met the inclusion criteria. The study was ongoing from 2002 to 2005.

The patients aged 6–18 years who were included had sustained severe brain injuries (Glasgow Coma Scale score < 8) and, on discharge from subacute rehabilitation (approximately 6–10 months after injury), still presented with marked attention deficits that affected both basic components and superordinate components.

Exclusion criteria included a medical history of past brain injury, preexisting psychiatric, ADHD, and cognitive (attention) or behavioral disorders (this information was collected from the families and from teachers who had known the children before their injury). Further exclusion criteria were as follows: rehabilitation provided at different sites and mental retardation (IQ < 50). Patients with an IQ < 50 were excluded, as such severe intellectual disability makes it difficult to specifically assess the disorder. Nineteen of the 108 excluded patients were in a vegetative or minimally responsive state, 8 had a previous psychiatric or neurological history, 37 could not be tested because of the seriousness of their neuropsychological profile, 14 had an IQ < 50, and 25 did not have attention problems at the time of the commencement of the study. Five patients who fulfilled the inclusion criteria were excluded because they had received the treatment elsewhere.

Upon discharge from subacute rehabilitation (baseline measures), all the selected patients were asked to participate in a 6-month attention remediation training program. Twenty-five patients who did not give their consent were included in the control group and agreed to come back for a 1-year follow-up assessment.

We did not conduct a randomized controlled trial because we believe that it is unethical to withhold treatment that clinicians strongly believe is of benefit. Several recent reviews of the medical literature have suggested that estimates of treatment effect sizes obtained from well-designed observational studies are comparable with those obtained from randomized controlled trials (Concato, Shah, & Horwitz, 2000). Moreover, in our department, half the patients came from outside the region. The patients who refused to
take part in the study did so because their homes were too far away from our institute. None of the patients refused to take part in the rehabilitation programs for any other stated reason. The Italian regions from which our patients came were a considerable distance away from our Institute, but they were no more disadvantaged than ours and the socioeconomic conditions of the individual patients were comparable in the two groups. The patients who underwent neuropsychological treatment in other rehabilitation centers were excluded, but there were only 5 of them. Both groups showed similar attention and cognitive skills and a comparable impairment in adaptive behavior. The people testing the children were unaware of their treatment status. The local research Ethics Committee approved the project, and all subjects gave their informed consent in line with the Declaration of Helsinki.

Our sample was made up of 65 patients with a TBI. Of these, 40 formed the experimental group and the remaining 25 patients formed the control group. The following demographic and clinical data were collected for each patient: sex, education, age at injury, age at assessment, time between injury and remediation, days of unconsciousness, main lesion site from Rivermead Mobility Index (RMI) score (by three different categories: frontal, posterior, and diffuse axonal damage), neurosurgery (yes/no), aphasia (yes/no), sensory disabilities (visual, auditory) or motor disabilities (hemiplegia, tetraplegia, ataxia). None of these sensory or motor deficits affected the test performance.

At study entry, all the patients received an age-appropriate multidisciplinary clinical–functional assessment including the following: neurological examination; psychiatric evaluation; ophthalmologic examination; ear, nose, and throat examination; audiometric testing; cognitive and psychological testing; and RMI score.

The parents cooperated in the collection of the medical history and also completed a scale for the assessment of adaptive behavior (from the VABS).

**Measures**

Cognitive testing included an IQ test: the Wechsler Intelligence Scale for Children—Revised (WISC–R; Orsini, 1993) or the Wechsler Adult Intelligence Scale—Revised (WAIS–R; Orsini & Laicardi, 1997), which provides three intellectual levels: full IQ (FIQ), verbal IQ (VIQ) and performance IQ (PIQ).

Attention skills were explored with the Continuous Performance Test II (CPT II Conners, 2000), a standardized and computerized attention test used both in research and in clinical practice. The CPT was originally devised to explore alertness in patients with epilepsy (Beck, Bransome, Mirsky, Rosvold, & Sarason, 1956). Since then, many studies have been conducted on the factors influencing alertness in individuals (Mackworth, 1957), which gave way to a family of CPTs with similar characteristics but different stimuli and responses. These CPT variants investigate the different components of attention. The CPT II was chosen because it was standardized on a wide normative sample; it has good discrimination ability for attention and can be administered to patients with motor deficits. The CPT II report is designed to help identify various combinations of measures that have clinical relevance. In particular, specific variables derived from the task are relevant to selective attention/response accuracy (frequency and nature of errors), processing speed (mean reaction times, slowed responses), and variability/inhibition (commission errors, missed responses, attentional lapses). In the CPT II, subjects are asked to press a button for any characters that appear on the screen, except for X. Characters are approx. 2.54 cm (1 in.) in width. Stimuli are subdivided into six sets, with three subsets of 20 cues each (both target and false cues). Subsets have different interstimulus intervals (ISIs): 1, 2, or 4 s. The interval order varies across blocks. Cues appear on the screen for 250 ms. The examiner explains the task to the participant, who has a trial run before carrying out the actual task. The test lasts 14 min.

In this study, we avoided the bias of the possible procedural learning of the task by administering the CPT II only at assessment and not during training. Conners (1995, 2000) has suggested that the CPT II is relatively unaffected by practice effects. High percentile values on the CPT II (>90) point to attention problems. However, low percentile values (<15) on some indices also reveal attention problems. Some score combinations highlight more specific types of attention disorders. The CPT II tests the following parameters:

- Omission: number of target cues to which the subject does not respond (omissions). If high, it is indicative of poor task orientation.
- Commission: number of commission errors (the subject responds to a non-target cue) or false alarms. If high, it is indicative of impulsiveness.
- Hit reaction time (Hit RT): mean response time for each cue. If low and associated with a large number of omissions, it is indicative of inattention. If unusually high and associated with frequent commissions, it may indicate impulsiveness.
- Standard error: the standard error of RTs enables the statistical reliability of the RTs to be determined. When the subject’s responses vary considerably during the test, the subject may have attention problems.
- Hit RT ISI: A measure of change of RTs across the three different ISIs.
- Hit RT × Block (Hit-Block): a measure of change of RTs across the six different sets of cues.
- Risk taking: individual response style. Some subjects are cautious and reflective and respond less frequently than the normative sample, making more omission errors. Others are more impulsive and respond more frequently, making more commission errors.
- Overall index: normal or pathological attention profile. High scores (>11) suggest attention disorders, scores between 8 and 11 are considered borderline or threshold scores, and scores lower than 8 are considered to be normal.

Table 1 shows a guideline for interpreting percentile measures.

To verify the ecological validity of the proposed training, parents completed the VABS Expanded Form 28. The VABS are designed to assess and measure adaptive behavior, defined as the individual’s performance in daily life activities which are necessary for personal and social independence. Data about four different domains of adaptive behavior are collected through a semi-structured interview with the parents or caregiver. These domains are communication, daily living skills, social skills and motor skills. The VABS are currently considered to be among the most applicable scales, as they show the best psychometric properties. For each age range, a maximum score indicates the individual’s full achievement of the tested ability. Scores are expressed as
percentages of the expected ability by age. They provide a measure of the subject’s adaptive behavior in the individual scale domains: the higher the score, the greater the subject’s adaptive skills. This measure was chosen because it was standardized on the basis of extensive normative data. Previous studies have shown that the VABS is a reliable measure for adaptive behavior in children and adolescents. This study only used the VABS domains that measured adaptive skills that required attention to be performed: communication, daily living skills, and social skills. Within these three domains, there are items that specifically investigate attentive behavior in daily life.

### Procedure

All patients were assessed at two different time points: baseline, at discharge from subacute rehabilitation; and follow-up, 1 year from baseline (WAIS, CPT II). The people testing the children were unaware of treatment status. The parents completed the VABS at baseline and follow-up.

Each experimental patient received attention-specific neuropsychological training, including tabletop tasks (Marzocchi, Molin, & Poli, 2000) and computerized tasks such as the Rehacom program (Schuhfried, 1996) and the Attenzione e Concentrazione program (Di Nuovo, 1992). The training took place four times a week and lasted 6 months, with individual sessions lasting 45 min. In each session, patients work one on one with a therapist for 30 min with computer-based activities and 15 min with tabletop tasks. The training was conducted only in our institute. The parents were not involved in the cognitive rehabilitation.

The tabletop tasks include interpretation of pictures and vignettes, giving answers to open and closed questions, and providing opinions and suggestions for the management of attention. The material used varied according to the subject’s chronological age. These tasks therefore targeted the following: selective attention, focused attention, sustained attention, divided attention, inhibition, and shifting. For each study area, reflection upon the way the various components of attention influence tasks was followed by a demonstration of strategies, which are apt to manage and control one’s cognitive functioning. This rehabilitation program targeted meta-attention with material stimulating a greater awareness of the subjects’ cognitive functioning, on the assumption that such awareness raising at an early age enables greater cognitive and behavioral control to be achieved.

### Tasks on Rehacom and Attenzione e Concentrazione

Computer tasks included Rehacom (Schuhfried, 1996) for patients aged 8–18 years and Attenzione e Concentrazione (Di Nuovo, 1992) for patients aged 6–8 years. The Rehacom remediation software includes tasks targeting a specific component of attention: (a) vigilance; (b) attention and concentration; and (c) response and response behavior.

**Vigilance.** Tasks aimed at enhancing vigilance and sustaining attention. The subject is required to select the elements that do not match the given template. Stimuli appear continuously onscreen, from the right to the left on a conveyor belt. The difficulty level depends on the total number of stimuli, the number of target stimuli, the type of stimuli (concrete/abstract), the length of the session, and the speed of presentation.

**Attention and concentration.** Tasks aimed at stimulating selective attention and the ability to inhibit irrelevant stimuli. The subject is asked to compare a template with a number of pictures shown onscreen.

The difficulty level depends on the number of stimuli onscreen (3, 6, 9) and the visual–perceptual complexity of the stimulus.

**Response and response behavior.** Tasks aimed at enhancing RTs and the accuracy of the response by stimulating sustained attention and the shifting ability (the Stroop phenomenon in the response training). The subject is required to respond readily to the target stimuli, using different response modalities (e.g., press OK if the red letter X appears onscreen, and press the right key if the blue circle appears).

The variables that define the degree of difficulty include the length of the task, the percentage of target stimuli, the presentation location onscreen, the number of required responses (up to four), and the stimulus orientation (e.g., right/left arrow) matching the location of the key to press (e.g., right/left arrow).

The Attenzione e Concentrazione software aims at enhancing the various components of attention: selective and sustained attention, attention span, divided attention, resistance to distraction, and shifting. Visual and auditory stimuli are presented with varying degrees of difficulty (easy, intermediate, difficult) according to the number of stimuli presented. The software includes specific attention tasks: (a) stimulus RTs, tasks aimed at decreasing RTs, and increasing response speed; (b) and attention span and forward/backward repetition of digits.

**Stimulus RTs, tasks aimed at decreasing RTs, and increasing response speed.** We measured selective and divided attention, selection of auditory or visual stimuli rather than responding to two parallel tasks (visual and auditory recognition; e.g., “Press ENTER when you hear the word SUN, and press SPACE when you see the BLUE STAR”). In the distraction resistance training, the task is based on the Stroop phenomenon.

**Attention span and forward/backward repetition of digits.** We measured attention shifting, a multiple search for letters (verbal channel), or symbols with different spatial orientation (visual–spatial channel). During the training, true or false answers were accompanied by visual and auditory feedback.

### Statistical Analysis

Data are presented as means, standard deviations, and percentages. Qualitative variables were investigated with the $\chi^2$ statistic and quantitative variables with the $t$ test. Comparison between the two groups
was performed by repeated measures analysis of variance (ANOVA), with group as the between-subjects factor and assessment time as the within-subjects factor. A p value <.05 (two-tailed) was considered to be significant. Bivariate correlation was used to assess the relationship between the change in attentive behaviors and the change in adaptive behavior. Linear multiple regression analysis was performed to verify whether the clinical variables days of unconsciousness, age at injury, and involvement in a specific remediation intervention influenced the rehabilitation outcome in the two groups. All statistics were performed with the SPSS 10.0.

Results

Sample Description

Our sample was made up of 65 TBI patients (aged 6–18 years). Of these, 40 (30 male [75%], 10 female [25%]) formed the experimental group, and the remaining 25 patients (16 male [64%], 9 female [36%]) formed the control group. The clinical and demographic data of the study group are shown in Table 2. The comparison between the experimental group and the control group by the χ² test and the t test did not reveal any significant differences.

Baseline Evaluation

At the baseline evaluation, the mean FIQ of both the experimental group (M = 68.61, SD = 18.11) and the control group (M = 61.21, SD = 16.27) was significantly lower than the mean of normal peers (M = 100, SD = 15) and falls within the range of a mild intellectual disability. On the CPT II, both groups scored high in the pathological range on indices for omission, risk taking, standard error, and the overall index. The Hit RT ISI scores were borderline for both groups.

With regard to the VABS, analyses revealed impairment in adaptive behavior in the domains of communication, daily living skills, and social skills for both groups.

Follow-Up Evaluation

At follow-up (1 year from baseline), the VIQ, the PIQ, and the FIQ of the experimental group had improved by 9.71, 10.52, and 11.45 points, respectively. These changes were significant in the t test: For the VIQ, t(31) = -3.753, p = .001; for the PIQ, t(32) = -4.090, p < .0001; for the FIQ, t(30) = -4.477, p < .0001. The t test statistics also revealed significant improvements in the CPT II, between the baseline and the follow-up: Omission, t(40) = 4.926, p < .0001; Commission, t(40) = -3.587, p = .001; Standard Error, t(40) = 6.495, p < .0001; Risk Taking, t(40) = 5.032, p < .0001; Hit Block, t(40) = 2.682, p = .011; Hit RT ISI, t(40) = 3.985, p < .0001;

Table 2

<table>
<thead>
<tr>
<th>Sample Clinical and Demographic Variables</th>
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<tbody>
<tr>
<td>Demographic</td>
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<tr>
<td>Sex (%)</td>
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<tr>
<td>Male</td>
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<tr>
<td>Female</td>
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<tr>
<td>Neurosurgical intervention</td>
</tr>
<tr>
<td>% Yes</td>
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<tr>
<td>% No</td>
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<tr>
<td>Language</td>
</tr>
<tr>
<td>% With deficit</td>
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<tr>
<td>% With no deficit</td>
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<tr>
<td>Hearing</td>
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<tr>
<td>% With deficit</td>
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<tr>
<td>% With no deficit</td>
</tr>
<tr>
<td>Vision</td>
</tr>
<tr>
<td>% With deficit</td>
</tr>
<tr>
<td>% With no deficit</td>
</tr>
<tr>
<td>Motor deficit</td>
</tr>
<tr>
<td>% Hemiplegia</td>
</tr>
<tr>
<td>% Tetraplegia</td>
</tr>
<tr>
<td>% Ataxia</td>
</tr>
<tr>
<td>% With no deficit</td>
</tr>
<tr>
<td>Lesion location</td>
</tr>
<tr>
<td>% Frontal</td>
</tr>
<tr>
<td>% Posterior</td>
</tr>
<tr>
<td>% DAI</td>
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</table>

Note. DAI = diffuse axonal injury.
Overall Index, $t(40) = 15.873, p < .0001$. At follow-up, the CPT II scores fell within the normal range.

The VABS showed significant improvements in all the study domains: For communication, $t(40) = -8.572, p < .0001$; for daily living skills, $t(40) = -8.523, p < .0001$; for social skills, $t(40) = -11.237, p < .0001$.

The control group showed significant improvements on the FIQ, $t(40) = -3.204, p = .005$, and on the PIQ, $t(40) = -3.692, p = .002$; specifically, they improved by 8.63 points on the FIQ and by 10.11 points on the PIQ. The VIQ improvement was not significant, $t(40) = -1.943, p = .068$. The CPT II showed significant improvement in the following indices: Omission, $t(23) = 2.108, p = .046$; Commission, $t(23) = 3.009, p = .006$; Standard Error, $t(23) = 2.914, p = .001$; Risk Taking, $t(23) = 2.601, p = .016$; Hit RT ISI, $t(23) = 2.158, p = .042$; and Overall Index, $t(23) = 5.495, p < .0001$. However, Omission, Standard Error, Risk Taking and Overall Index remained markedly atypical. Last, the control group did not show any significant improvement on the VABS domains: For communication, $t(23) = -2.019, p = .057$; for daily living skills, $t(23) = -2.025, p = .055$; for social skills, $t(23) = -1.382, p = .180$.

Comparison Between the Groups

Table 3 shows the mean IQ, CPT II, and VABS scores of the clinical group and the control group at baseline and follow-up. In the same table, a comparison between the clinical group and the control group was performed with a repeated measures ANOVA, with group as the between-subjects factor and assessment time as the within-subjects factor. With regard to the IQ evaluation, we found no significant differences between the two groups. We found significant differences in attention performance between the two groups between baseline and follow-up in the CPT II. The statistical analysis revealed significant differences in the following CPT II indices: Overall Index, $F(1, 35) = 159.79, p < .0001, \eta^2 = .820$; Omission, $F(1, 35) = 18.66, p < .0001, \eta^2 = .348$; Commission, $F(1, 35) = 5.76, p = .022, \eta^2 = .141$; Hit RT, $F(1, 35) = 9.88, p = .003, \eta^2 = .220$; Standard Error, $F(1, 35) = 33.91, p < .0001, \eta^2 = .492$; Risk Taking, $F(1, 35) = 15.19, p < .0001, \eta^2 = .303$. The clinical group improved more than the control group.

A comparison of the performances on the VABS showed a significant difference in the three domains. For communication, $F(1, 63) = 50.19, p < .0001, \eta^2 = .443$; for daily living skills, $F(1, 63) = 49.29, p < .0001, \eta^2 = .439$; and for social skills, $F(1, 63) = 69.38, p < .0001, \eta^2 = .524$. The clinical group improved more than the control group.

Ecological Validity of Remediation Intervention

To assess the ecological validity of the rehabilitation treatment, we calculated the correlations between change scores in the Overall Index of CPT II and scores in the three domains of the VABS in terms of the differences ($\Delta$) between the scores achieved by the patients of the two groups at the baseline assessment and at follow-up (bivariate correlations). Significant correlations were revealed only for the clinical group between change in Overall Index and the VABS scores in two domains: communication ($r = -.426, p < .0001$) and daily living skills ($r = -.246, p < .0001$). The reduction in attention deficit in the clinical group was associated with an increase in adaptive skills essential for communication and interpersonal relationships.

Table 3
Comparison Between Clinical and Control Groups, With Mean IQ, CPT II, and VABS Scores (and Standard Deviations) at Baseline and Follow-Up

<table>
<thead>
<tr>
<th>Test</th>
<th>Clinical group</th>
<th>Control group</th>
<th>ANOVA group × assessment F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Follow-up</td>
<td>Baseline</td>
</tr>
<tr>
<td>IQ</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIQ</td>
<td>72.97 (16.90)</td>
<td>82.68 (16.26)</td>
<td>67.16 (15.41)</td>
</tr>
<tr>
<td>PIQ</td>
<td>69.45 (18.99)</td>
<td>79.97 (16.58)</td>
<td>60.52 (16.67)</td>
</tr>
<tr>
<td>FIQ</td>
<td>68.61 (18.11)</td>
<td>80.06 (16.29)</td>
<td>61.21 (16.27)</td>
</tr>
<tr>
<td>CPT II</td>
<td></td>
<td></td>
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<tr>
<td>Omission</td>
<td>91.86 (11.96)</td>
<td>76.01 (24.19)</td>
<td>95.87 (6.02)</td>
</tr>
<tr>
<td>Commission</td>
<td>63.66 (30.21)</td>
<td>46.46 (30.97)</td>
<td>71.84 (30.01)</td>
</tr>
<tr>
<td>Hit RT</td>
<td>33.33 (34.91)</td>
<td>36.56 (28.68)</td>
<td>42.66 (30.09)</td>
</tr>
<tr>
<td>Standard Error</td>
<td>88.66 (19.50)</td>
<td>66.14 (26.17)</td>
<td>93.63 (10.78)</td>
</tr>
<tr>
<td>Risk Taking</td>
<td>92.27 (15.82)</td>
<td>75.21 (26.44)</td>
<td>94.31 (13.88)</td>
</tr>
<tr>
<td>Hit Block</td>
<td>65.34 (33.12)</td>
<td>51.35 (23.09)</td>
<td>69.08 (35.23)</td>
</tr>
<tr>
<td>Hit RT ISI</td>
<td>83.87 (25.43)</td>
<td>64.00 (26.99)</td>
<td>78.21 (31.35)</td>
</tr>
<tr>
<td>Overall Index</td>
<td>15.31 (4.17)</td>
<td>5.40 (4.68)</td>
<td>16.75 (4.29)</td>
</tr>
<tr>
<td>VABS domain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>65 (21)</td>
<td>94 (9)</td>
<td>63 (26)</td>
</tr>
<tr>
<td>Daily living skills</td>
<td>70 (19)</td>
<td>94 (9)</td>
<td>68 (23)</td>
</tr>
<tr>
<td>Social skills</td>
<td>69 (13)</td>
<td>95 (9)</td>
<td>63 (22)</td>
</tr>
</tbody>
</table>

Note. The comparison was performed with repeated measures analysis, with group as the between-subjects factor and assessment time as the within-subjects factor. ANOVA = analysis of variance; VIQ = Verbal IQ test; PIQ = Performance IQ test; FIQ = Full IQ test; CPT II = Continuous Performance Test II; RT = reaction time; ISI = interstimulus interval; VABS = Vineland Adaptive Behavior Scales.

*p < .05. **p < .01. ***p < .001.
**Effect of Clinical Variables on Attention Performance**

We performed a linear regression analysis by using three independent variables: age at injury, days of unconsciousness, and involvement in specific remediation intervention (see Table 4). The aim of this analysis was to assess the effect of these variables on attention performance evaluated through the Overall Index at the follow-up assessment. The two variables that influenced the scores significantly were the days of unconsciousness \( p = .037 \) and specific remediation intervention \( p < .0001 \); the Overall Index scores were higher in the patients who had a longer period of unconsciousness and who did not undergo the treatment. Specifically, the standardized beta coefficient, which evaluates the importance of the different factors and eliminates the effect of the varied units of measurement, suggests that not having undergone the treatment had a greater influence \( (\beta = 0.547) \), than the length of coma \( (\beta = 0.238) \). Age at injury did not have any influence on the attentive performance.

**Discussion**

We studied a group of children and adolescents (aged 6–18 years) with TBI and presenting with attention deficits to describe their attention profile and evaluate the efficacy of neuropsychological remediation training through comparison with a control. The training studied in this work derives from a reassessment of the models proposed in the literature and is based on our long clinical experience in the rehabilitation of children and adolescents with serious head injuries (Butler & Copeland, 2002; Lisco et al., 2003; Thompson, 1995; Thompson & Kerns, 2000).

At baseline, the experimental group and the control group presented with a mild intellectual disability and a specific-attention deficit, as shown by the CPT II Overall Index scores. More specifically, the CPT II revealed pathological scores in some indices: Omission, Standard Error, Risk Taking, and Overall Index. Omission is considered to be a measure of inattention (Conners, 2000), measuring the inability of the subject to select only target stimuli among nontarget stimuli. Standard Error is a measure that enables the reliability of RTs to be assessed. These values show that RTs changed throughout the test and suggest an impairment of sustained attention, as the subject was not able to stay concentrated on the task throughout its performance.

Hit RT ISI scores are mildly atypical. They are a measure of RT changes across the three ISIs. RTs vary substantially across the ISIs, and this suggests that the subjects were susceptible to distraction. Our group showed high Risk Taking scores, which means that some patients have difficulty in controlling their response set and are impulsive. Hit RT scores, which are a measure of processing speed, show an extremely high standard deviation. This is indicative of highly heterogeneous performances in RTs and applies both to subjects with a marked delay in response (RT > 90) and to subjects with marked impulsiveness (RT < 15). Our data support previous studies in the literature that have reported a frequent ideomotor delay, or impulsiveness, in TBI patients (Cicerone, 1996; Rios, Periáñez, & Muñoz-Céspedes, 2004; Leblanc et al., 2005). High RTs or worsening performances under time pressure reflect a clear processing delay (Ponsford & Kinsella, 1992; Tromp & Mulder, 1991). On the other hand, impulsiveness reflects a functional deficit in response control and a strategic allocation of attention resources (Prather & Kaplan, 1991).

At follow-up, the experimental group showed an improvement in the FIQ, VIQ, and PIQ: the mild intellectual disability had evolved to an intellectual ability in the lower limit of the normal range. The remediation training clearly improved attention performance, as shown by the Overall Index: at the 1-year follow-up, the subjects’ attention performance had normalized. More specifically, inattention errors (Omission) had decreased in number and the subjects maintained their attention longer. Training had also reduced the subjects’ impulsiveness, as shown by lower Risk Taking scores at the 1-year follow-up. There was also an improvement in the ability to adjust response speed to the changing ISIs.

At follow-up, the control group showed an improvement in the FIQ and the PIQ, but no significant changes were found in the VIQ. These subjects still showed a mild intellectual disability. Furthermore, the control group showed a significant improvement in the CPT II, but the single scores remained pathological, which suggests an attention-specific deficit.

It is known that a spontaneous neuropsychological recovery takes place after brain injury. Moreover, these findings are particularly interesting in that they support our hypothesis that environmental stimulation (e.g., school, family, sensory stimulation), together with general different rehabilitation interventions (e.g., physical therapy), may promote an increase in global attention to the environment and an improvement in cognitive function when the subjects return home and resume their daily habits. However, levels of normality are not achieved, and this has an impact on functional recovery. The specific neuropsychological rehabilitation helps the subjects move closer to normality and has a positive influence on adaptive skills.

To verify whether the improvements in performances and scores of the experimental group were due to the attention-specific training, we made a comparison with the control group. Significant differences on the CPT II were found between the two groups: the experimental group showed a global improvement in attention (Overall Index) and a reduction in omission errors and impulsiveness, and they were more concentrated on the task. In contrast, the control group still showed an attention-specific deficit, although their attention performance had improved since the subacute phase.

The attention training thus significantly influences the CPT II performance and improves the attention skills affected by the TBI: Patients who received specific remediation training were less distracted, were able to concentrate for a longer period of time, were more reflective and less impulsive, and performed the test accurately.

### Table 4

**Data From the Independent Variables Used in Linear Regression Analysis**

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>( B )</th>
<th>( SE \ B )</th>
<th>( \beta )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at injury</td>
<td>-0.005</td>
<td>0.012</td>
<td>-0.045</td>
</tr>
<tr>
<td>Days of unconsciousness</td>
<td>0.067</td>
<td>0.031</td>
<td>0.224*</td>
</tr>
<tr>
<td>Involvement in rehabilitation</td>
<td>6.91</td>
<td>1.19</td>
<td>0.606**</td>
</tr>
</tbody>
</table>

*Note.* Overall index was used as the dependent variable.

*p < .05. **p < .01. ***p < .001.*
One of the strengths of this study is the investigation of the ecological validity of the attention-specific remediation by using the VABS; this field is relatively unexplored in the literature (Limond & Leeke, 2005). Some studies show improvements in specifically trained tasks, which tells us only about that task and not about the generalizability of the intervention. None of the reviewed studies examined the validity of their outcome measures (Limond & Leeke, 2005). At baseline, the data collected by the VABS showed that cognitive deficits affect the social adaptive skills of individual patients in both groups. In particular, all three investigated domains were disturbed. At the 1-year follow-up, the experimental group had significantly improved in all three domains, whereas no significant improvement was found for the control group. The between-groups comparison showed a greater improvement in the experimental group in all three domains.

In support of our hypothesis that the improvements in attention positively influence adaptive behavior in the context of everyday life, we verified the correlation between the CPT II Overall Index and the three domains of the VABS. The results we obtained suggest that there is a significant association, for the clinical group, between the reduction of the attention deficit and the increase in adaptive behavior, particularly in the context of communication and adaptive skills. In fact, the behavior investigated in these two contexts requires attention skills for it to be performed adequately. These data are encouraging as they testify in favor of the ecological validity of our treatment and deserve further investigation.

Furthermore, we set out to investigate the effect of age at trauma, days of unconsciousness, and specific remediation intervention in the global attention improvement (Overall Index) measured at the 1-year follow-up. The linear multiple regression applied to our findings showed that days of unconsciousness and specific remediation intervention are predictive of the results of the training. Moreover, the beta coefficient suggests that having had training has more influence than the length of the coma. These data emphasize the importance of rehabilitation training, which has had a greater influence on the attention outcome in our sample, compared with a significant clinical variable such as the length of unconsciousness. The literature reports (Anderson et al., 2000; Anderson & Pentland, 1998; Murray et al., 1992) that a trauma sustained at an early age causes more pervasive lesions, because it affects a cognitive system that is still developing. Our findings, however, lead us to suggest that, if timely, an attention-specific and metacognitive intervention can favor the development of higher cognitive functions, of which attention is a precursor. In particular, the attention disorder in childhood—mainly characterized by restlessness, easy distractibility, and impulsiveness (Brink, Garrett, Hale, Nickel, & Woo-Sam, 1970; Hanney, 1994)—leads to superficial scanning of information, misinterpretations, omissions, inappropriate decisions, and perseverations (Jaffe et al., 1992). Remediation training for children should therefore specifically target attention, followed by the correct application and generalizability of cognitive procedures and the most effective strategies for learning.

Conclusions

Attention functions are almost always impaired in TBI patients, and this deficit affects formal learning and school entry. In childhood and adolescence, these aspects are crucial for recovery and re-entry into society. For this reason, we investigated a primary function such as attention and showed that remediation is fundamental for recovery. Spontaneous recovery of attention occurs only partially; our study indeed shows that, if left untreated, attention deficits tend to stabilize over time. Our findings show that specific remediation training for attention, including a combination of a process-specific approach and metacognitive strategies, significantly improves the performances of treated patients versus a comparable group of untreated patients. The improvement in these skills stems directly from the remediation intervention, whereas the cognitive level partly benefits from other factors. Furthermore, an improvement of attention skills correlates with an improvement in the patient’s social and adaptive skills in ecological contexts. This finding supports our hypothesis that an attention-specific remediation intervention could have ecological validity and enables the primary goal of rehabilitation to be achieved: an improvement in the quality of life of patients with TBI. Considering the significance of this topic and given the scarce literature available, we believe that it would be appropriate to investigate our results further by introducing the use of other ecological measures and parent/significant other reports.

A limitation of this study is the lack of a VABS scale relating to the preinjury level of adaptive behavior, which would complete the information given by the parents and teachers while the medical history is taken. It would enable us to estimate the effect of the brain injury on adaptive skills and to quantify more precisely the positive effect of our treatment on functional recovery. Attention is the substrate of the higher cognitive functions and of some adaptive behaviors and must therefore be a priority of remediation interventions.

References


Call for Nominations: Psychology of Violence

The Publications and Communications (P&C) Board of the American Psychological Association has opened nominations for the editorship of Psychology of Violence, for the years 2011–2016. The editor search committee is chaired by William Howell, PhD.

Psychology of Violence, to begin publishing in 2011, is a multidisciplinary research journal devoted to violence and extreme aggression, including identifying the causes and consequences of violence from a psychological framework, finding ways to prevent or reduce violence, and developing practical interventions and treatments.

As a multidisciplinary forum, Psychology of Violence recognizes that all forms of violence and aggression are interconnected and require cross-cutting work that incorporates research from psychology, public health, neuroscience, sociology, medicine, and other related behavioral and social sciences. Research areas of interest include murder, sexual violence, youth violence, inmate aggression against staff, suicide, child maltreatment, bullying, intimate partner violence, international violence, and prevention efforts.

Editorial candidates should be members of APA and should be available to start receiving manuscripts in early 2010 to prepare for issues published in 2011. Please note that the P&C Board encourages participation by members of underrepresented groups in the publication process and would particularly welcome such nominees. Self-nominations are also encouraged.

Candidates should be nominated by accessing APA’s EditorQuest site on the Web. Using your Web browser, go to http://editorquest.apa.org. On the Home menu on the left, find “Guests.” Next, click on the link “Submit a Nomination,” enter your nominee’s information, and click “Submit.”

Prepared statements of one page or less in support of a nominee can also be submitted by e-mail to Emnet Tesfaye, P&C Board Search Liaison, at Emnet@apa.org.

Deadline for accepting nominations is January 31, 2009, when reviews will begin.

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