

Attention training in Attention Deficit Hyperactivity Disorder

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Pharmacological treatment of children with attention deficit hyperactivity disorder (ADHD) has been shown to be successful. However, children with ADHD on medication may still show attention deficits. We have assessed the effect of attention training on attention measures in children with ADHD. These children were randomly assigned to one of two conditions, i.e. an attention training which trained aspects of vigilance, selective attention and divided attention or a visual perception training which trained perceptual skills. They received eight individual training sessions over a period of four weeks. A group of control children did not receive any training. Vigilance, selective attention, divided attention and flexibility were assessed before and after the trainings. ADHD children were assessed and trained on medication. The attention training led to improvements of various aspects of attention, including vigilance, divided attention and flexibility, while the visual perception training showed no effects. These findings indicate that attention training programs have the potential to facilitate attentional functioning in children with ADHD.

Keywords: ADHD, attention training, visual perception training.

Entrenamiento atencional en Trastorno por Déficit de Atención con Hiperactividad. El tratamiento farmacológico en niños con Trastorno por Déficit de Atención e Hiperactividad (TDAH) ha demostrado tener éxito. Sin embargo, los niños con TDAH medicados pueden todavía mostrar déficits de atención. Hemos evaluado el efecto del entrenamiento de la atención sobre medidas de atención en niños con TDAH. Estos niños fueron asignados aleatoriamente a una de dos condiciones experimentales: un entrenamiento de la atención centrado en desarrollar la vigilancia, la atención selectiva y la atención dividida; o un entrenamiento de la percepción visual para desarrollar habilidades perceptivas. Los niños recibieron ocho sesiones de entrenamiento individual durante un período de cuatro semanas. Un grupo de niños control no recibió ningún entrenamiento. La vigilancia, la atención selectiva, la atención dividida y la flexibilidad fueron evaluadas antes y después de los entrenamientos. Los niños con TDAH fueron evaluados y entrenados bajo los efectos de la medicación. El entrenamiento de la atención dio lugar a mejoras de diversos aspectos atencionales, incluyendo la vigilancia, la atención dividida y la flexibilidad, mientras que el entrenamiento de la percepción visual no mostró efectos. Estos hallazgos indican que los programas para el entrenamiento de la atención pueden facilitar el funcionamiento atencional de los niños con TDAH.

Palabras clave: TDAH, entrenamiento atencional, entrenamiento en percepción visual.

Inattention is one of the core symptoms of attention deficit hyperactivity disorder (ADHD) (Lange *et al.*, 2010). Pharmacolog-

ical treatment using stimulant medication has consistently been found to improve the attention deficit in children with ADHD. For example, Tucha *et al.* (2006c) applied a multi-dimensional model of attention and found that children with ADHD present with a global deficit of attention comprising impairments of vigilance, selective attention, focused atten-

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tion, divided attention and shifting. Pharmacological therapy with methylphenidate has been shown to significantly improve all impaired functions of attention (Tucha *et al.*, 2006a, 2006b). Although beneficial effects of medication were observed, children with ADHD did not reach an undisturbed level of attention. These observations indicate a need for additional treatment of the attention deficit in children with ADHD.

Pharmacological treatment has been shown to be effective alone and appears to be the most effective part of comprehensive multi-modal treatment (Greenhill, 1992; Pelham *et al.*, 1992; Wilens & Biederman, 1992). However, other approaches such as attention training programs may add to the success of medication.

Previous studies (Kerns *et al.*, 1999; Semrud-Clikeman *et al.*, 1999; Tamm *et al.*, 2010) have indicated that training of attention can improve attentional functioning in children with ADHD. Our study attempted to evaluate the effectiveness of a deficit-specific approach in the treatment of attention deficits of children with ADHD. It has been shown that specific deficits of attention require the use of specific training tasks designed to address these deficits (Sturm & Willmes, 1991; Sturm *et al.*, 1997). The commercially available program *AixTent* (Sturm *et al.*, 2001) was used. *AixTent* allows the treatment of disturbances of alertness, vigilance, selective attention and divided attention which have been found to be impaired in children with ADHD (Lange *et al.*, 2007; Tucha *et al.*, 2006b, 2006c, 2009).

Method

Participants

Thirty-two children with ADHD according to DSM-IV criteria as diagnosed by child and adolescent psychiatrists participated in the study. Twenty-seven children met diagnostic criteria for an additional comorbid psychiatric condition such as attachment disorders ($n=9$), specific reading and/or spelling disorders ($n=8$) or adjustment disorders ($n=4$). Since psychiatric comorbidities are common in children with ADHD (Kadesjo *et al.* 2001; Szatmari *et al.*, 1989), psychiatric comorbidity was no reason for exclusion. At the time of the study, all children with ADHD were being treated with ADHD medications (stimulants $n=30$; selective noradrenaline re-uptake inhibitor $n=2$). Children with ADHD continued taking their medication throughout the intervention and were randomly assigned to one of two groups. In the "attention training" group ($n=16$; 5 girls, 11 boys; mean age \pm SEM 10.8 ± 0.4 years, mean IQ \pm SEM 101.6 ± 2.9), children with ADHD received a specific training of attention functions (AixTent; Sturm *et al.*, 2001). Children in the "perception training" group ($n=16$; 5 girls, 11 boys; mean age \pm SEM 11.0 ± 0.6 years, mean IQ \pm SEM 99.7 ± 2.6) participated in a training of visual perception (*Frostig Developmental Program of Visual Perception*; Frostig *et al.*, 1972).

Furthermore, 16 healthy children ($n=16$; 5 girls, 11 boys; mean age \pm SEM 10.7 ± 0.4 years, mean IQ \pm SEM 103.6 ± 1.3) were assessed. None of these children had any history of neurological or psychiatric disease or displayed signs of ADHD or learning disability. No healthy participant was taking medication known to affect the central nervous system. Statistical comparison between groups indicated that the three groups did not differ with regard to sex, age or IQ. All parents were informed of the aims and nature of the study and gave their written consent.

Attention measures and training

Computerized tests of attention (Zimmermann & Fimm, 1993, 2002) were applied measuring aspects of selective attention, vigilance, divided attention and flexibility. These measures have been shown to be sensitive to the impairments of children with ADHD (Tucha *et al.*, 2006a, 2006b, 2009). Children with ADHD were examined before and after training, healthy children only once. Children of both training groups (attention or perception) received eight individual training sessions of about one hour over a period of four consecutive weeks. Control children did not receive any training.

Attention measures and training

The computerized attention training program *AixTent* was developed on the basis of results of clinical studies indicating that different

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aspects of attention can be impaired selectively and that unspecific training programs are not very efficient in the training of different components of attention (Sturm & Willmes, 1991; Sturm *et al.*, 2001). The program comprises training procedures that allow the specific training of different components of attention. The children with ADHD assigned to this program performed trainings of vigilance, selective attention and divided attention (Tucha *et al.*, 2011). The efficacy of the AixTent program has been demonstrated in patients with unilateral brain lesions of vascular etiology (Sturm *et al.*, 1994, 2001). The Frostig Developmental Program of Visual Perception (Frostig *et al.*, 1972; German version by Reinartz & Reinartz, 1974) was used as an unspecific training program. This program was developed for the training of elementary school students with impaired visual-perceptual abilities.

Results and discussion

Data analysis revealed that our attention training led to improvements of vigilance, di-

vided attention and flexibility, as indicated by a decrease in commission errors (Table 1), while the visual perception training had no effects.

Previous research demonstrated that children with ADHD show various cognitive deficits despite successful pharmacological treatment (Gualtieri & Johnson, 2008). A study on the effects of drug treatment showed that stimulants do not normalize attention in ADHD children (Tucha *et al.*, 2006b). In our study, ADHD children showed considerable deficits of vigilance, selective attention, divided attention and flexibility, although they favorably responded to their medication. The impairments of ADHD children were reflected in poorer task accuracy as indicated by increased numbers of omission and commission errors. Therefore, children with ADHD on pharmacological treatment do not necessarily reach an undisturbed level of attentional functioning.

In the present study, a computerised attention training was applied in addition to pharmacological therapy. Various components of

Table 1. Omission and commission errors of control children and children with ADHD before and after training (means \pm SEM)

	CONTROL	ADHD			
		Attention training Before	After	Perception training Before	After
<i>Vigilance</i>					
Omission	3.1 \pm 0.5	6.8 \pm 1.1 ^A	5.9 \pm 1.2	7.1 \pm 0.8 ^A	8.1 \pm 1.1 ^A
Commission	3.5 \pm 0.8	16.1 \pm 6.3 ^A	8.6 \pm 3.2 ^B	8.1 \pm 1.9 ^A	8.3 \pm 1.6 ^A
<i>Selective attention</i>					
Omission	1.9 \pm 0.5	4.8 \pm 0.9 ^A	3.3 \pm 1.0	4.6 \pm 0.9 ^A	4.9 \pm 0.8 ^A
Commission	0.6 \pm 0.2	1.8 \pm 0.7	1.2 \pm 0.4	0.4 \pm 0.2	0.9 \pm 0.3
<i>Divided attention</i>					
Omission	1.0 \pm 0.2	4.4 \pm 0.9 ^A	4.5 \pm 1.4 ^A	4.6 \pm 0.8 ^A	5.1 \pm 0.7 ^A
Commission	0.7 \pm 0.2	2.9 \pm 0.9 ^A	0.6 \pm 0.2 ^B	2.4 \pm 0.5 ^A	2.4 \pm 0.5 ^{A,C}
<i>Flexibility</i>					
Commission	2.6 \pm 0.3	8.6 \pm 2.1 ^A	5.9 \pm 1.1 ^{A,B}	8.6 \pm 2.1 ^A	6.2 \pm 1.1 ^A

A - $p < .05$ when compared with control children (Mann-Whitney U-test)

B - $p < .05$ when compared with performance before training (Wilcoxon test)

C - $p < .05$ when compared with attention training after training (Mann-Whitney U-test)

attention were considered both in the selection of the test procedures and in the selection of procedures for the training of attention functions. These selections were made on the basis of the model by Van Zomeren & Brouwer (1994), which is based on the multi-component model of Posner & Boies (1971) and Posner & Rafal (1987), the distinction between selectivity and intensity of attention made by Kahneman (1973) and the concept of a supervisory attentional control as devised by Shallice (1982). In our attention training, procedures for the specific training of vigilance, selective and divided attention were used.

Our results indicate that the attentional functioning of children with ADHD benefits from a specific training of attention. The improvements observed in the children of the attention training group are unlikely to have resulted from the fact that the same test procedures were used both before and after training, because such practice effects were not found in the children of the perception training group. Furthermore, it can be excluded that the present findings resulted from a comparison of different populations since participants were randomly assigned to the two programs and the groups did not differ in attentional functioning before the training.

It is unclear what an improvement of neuropsychological test scores means in real life, i.e. the ecological validity of assessment and the external validity of results remain to be evaluated. Some authors used behavioral rating questionnaires for teachers, clinicians and/or parents beside neuropsychological

measures. While Kerns *et al.* (1999) found no significant treatment effects, Tamm *et al.* (2010) observed that parents and clinicians reported significantly fewer ADHD symptoms in children with ADHD following completion of an attention training. However, it is not clear whether the reduction in symptoms and the improvements of attentional functioning measured in the laboratory have any impact on the children's everyday life including an improvement of academic performance or social behavior. In addition, whether or not an attention training has lasting effects on children's attention remains to be investigated, since our and other studies did not assess the performance later than immediately after completion of the training.

Conclusions

The findings of our study support previous reports which found that attention training programs have the potential to facilitate attentional functioning in children with ADHD. Training programs with as few as eight 60-minute sessions appear to have positive effects on laboratory measures of attention. The effects of attention training on everyday functioning of children with ADHD remain to be established. Neuropsychological training programs of attention may provide promising and effective therapy without the side-effects of medication. In addition, the evaluation of the sole use of training attention functions off medication seems to be interesting in children with ADHD.

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