

**Seeking an alternative to medication for treating ADHD:
Is EEG Biofeedback the answer?**

Professor Karen J Pine, University of Hertfordshire

**THIS IS A PRE-PRINT OF AN ARTICLE THAT
APPEARED IN EVERY CHILD JOURNAL 2010**

1, 4, pp. 29-32.

Summary and Biography

This article describes a pilot trial of a new system for treating attention deficit and hyperactivity disorder (ADHD) in children. ADHD is a common problem, particularly in boys, and may look very similar to a conduct disorder, or simply bad behaviour. However research points to ADHD being a brain disorder and is now commonly treated with medication. Since drugs can have side effects and not all children respond to them, there has been a drive towards finding alternative forms of treatment.

Electroencephalography (EEG) biofeedback training may offer some hope. In this pilot study children used a thought-controlled computer game system to help improve their concentration and attention. After a relatively short period of training the children began to show a reduction in impulsivity, one of the core symptoms of ADHD. Although it is early days, this type of system may be the way forward to finding a solution to ADHD and an alternative to medicating children.

Professor Karen J Pine is Professor of Developmental Psychology at the University of Hertfordshire. She has a PhD in children's learning and has carried out research in developmental psychology for nearly 20 years, publishing her findings in academic journals and presenting at conferences worldwide.

Seeking an alternative to medication for treating ADHD:

Is EEG Biofeedback the answer?

Professor Karen J Pine, University of Hertfordshire

Attention deficit and hyperactivity disorder (ADHD) is a growing problem and one that affects not just the child, but parents, teachers and our wider society. The prevalence rate of ADHD in children was reported as being between 3 and 7% by the American Psychiatric Association in 1994, and is widely thought to be on the increase. That means that in a class of 25 to 30 children at least one is likely to have ADHD. If you're a teacher you'll have no doubt who that one is, and it is three times more likely to be a boy than a girl. Children with ADHD show chronic and consistent inattention, hyperactivity and impulsiveness. As any teacher or parent who has come across ADHD will testify, it is a particularly intrusive, disruptive and socially undesirable disorder. The noisy, active and sometimes dangerous behaviour it engenders means the child with ADHD will be perceived by many as simply badly behaved, a perception that merely adds to the difficulties facing the child's parents and teachers. The prognosis for the child is not good either. Research has shown that children with ADHD are more likely to develop academic, mood, behavioural and anxiety disorders¹. Later on in life these children are more likely to be substance abusers, to suffer psychiatric disorders, engage in criminal behaviour and their job prospects are pitifully poor².

The majority of research points to ADHD being a brain disorder, rather than a behavioural problem, and one that is often inherited. Therefore it lends itself well to treatment with drugs that moderate the functions of the brain. Many controlled group studies have found that medication is an effective form of treatment. However around 25% of ADHD sufferers develop adverse side effects or simply do not respond to medication^{3,4}. Other researchers⁵ have also found that only a small number of ADHD patients show enough improvement to put them within the normal range, even after being on medication. Apart from the simple fact that drugs produce side-effects and do not work for all, there remains a moral and ethical concern about medicating children for symptoms that are, on the face of it, merely inconvenient to society. However, given that ADHD blights the children's lives in so many ways, there is an imperative to find alternative non-pharmacological treatments.

One possible alternative is Electroencephalography (EEG) biofeedback training. This was developed from research looking at the relationship between surface EEG and the underlying brain activity. In the 1990's, US researcher Sternum found that differences in alertness and behavioural control were related to specific thalamocortical generator mechanisms in the brain. These differences are detectable as distinctive EEG frequency rhythms. The brain of the ADHD sufferer has different frequency rhythms and, if these could be normalized, attention and behavioural control might improve without the need for drugs.

During the past three decades researchers have been using EEG biofeedback training with ADHD with promising results. These studies have typically involved rewarding the ADHD patient for concentrating and producing a change in their own brain activity. A modern manifestation of this is the thought-controlled computer game. This came to the attention of my research team in 2009 and we conducted a trial with children with ADHD to see for ourselves whether it would help ameliorate their symptoms.

The EEG Biofeedback training system

We administered EEG biofeedback using a Play Attention helmet and corresponding Play Attention software. The helmet looks very similar to a bicycle helmet and contains a number of sensors in its lining. These sensors monitor the brain activities associated with mental effort and pick up whether or not the child is concentrating.

Once the child has the helmet on information from the Play Attention interface box is passed onto a laptop computer (via wireless technology). This allows a computer game to begin, as long as the child is attending. Effectively, the child's attention is 'powering' the games on the laptop, of which there are six in total: Attention Stamina, Visual Tracking, Time on Task, Short Term Memory, Discriminatory Processing and Academic Bridge.

The Attention Stamina game teaches the child to sustain their attention for five minutes. It has an underwater scene, with appropriate background sounds, and the child's concentration efforts make a diver drift towards the bottom of the screen, the seabed, where he collects points in the form of gold coins (see Figure 1). As soon as the child's attention wanders the diver stops, so only by maintaining concentration can the child obtain the desired reward.



Figure 1. Screenshot of Beginner level Attention Stamina game

The Visual Tracking game teaches the child to concentrate on several items on screen. By paying attention and clicking on boxes that light up the child can earn more points. The Time on Task game trains the child to maintain attention for a period of time, to complete a project as quickly as possible. The Discriminatory Processing is a spaceship game that encourages sustained attention while filtering out distractions. By maintaining attention, the child navigates a spaceship, allowing certain rocks to hit the spaceship and deflecting others to gain points.

Finally, the Academic Bridge game helps the child transfer the skills they have learned to an academic task. In this game, the child does some homework or a class task and, while they stay on task and maintain attention, a city scene is built on the computer screen.

The first 5 games have beginner, intermediate and advanced levels. They increase in difficulty in terms of the level of distraction presented to the child. At higher levels of the Attention Stamina games, for example, the child has to keep paying

attention even though larger objects appear on screen as distractions. Children can progress to a higher level once they have achieved 80% time on task for three consecutive sessions for a particular game. Points are not earned during any periods of non-attention so children quickly learn that sustained concentration will bring them the desired rewards.

Evaluating the system: the research

With the help of Hertfordshire educational psychologist, Dr. Rob Sharp, and the cooperation of local schools and parents, we selected ten children with ADHD to take part in a trial of the Play Attention EEG biofeedback system. For a period of 12 weeks during the summer term, researchers visited the children in school three times a week. They spent between 20 and 35 minutes playing the games at each session. The researchers, Farjana Nasrin and Catherine Khan, were undertaking a Master's level course in psychology under my supervision and received training from the Play Attention supplier, a not-for-profit organisation called Games For Life.

At the beginning and end of the study we collected data on a range of variables that the literature had suggested might be amenable to change by this type of intervention. The tests were the Test of Variables of Attention (TOVA) a computerized visual continuous performance test, the Weschler Intelligence Scale tasks (digit span task and picture completion task) and a Self Esteem Scale. In addition parents and teachers gave us their views on the child's behaviour, using the IOWA Connors Behaviour Rating Scales. Although we also recruited a control group, some data were missing from this group so we focused our data analysis on the changes in the children after using Play Attention for 12 weeks.

I should point out here that we were not optimistic about finding statistically significant changes on the variables. This is partly because we were testing quite a small sample, which compromises statistical power. Also, many studies say that at least six to nine months are necessary to produce sustainable change and allow for medication 'wash-out'. Pragmatic arrangements meant we just had to see what could be accomplished within a 12-week period. We knew that reaching the criteria laid down for evidence of efficacy⁶ would be a tall order, but hoped that, nonetheless, we would be able to detect the first signs that the children were improving.

The findings

One key finding emerged from all the data that we collected. The Test of Variables of Attention captures a number of variables including the child's 'commission errors'. That is when the child reacts unnecessarily, a measure of impulsivity. The average number of commission errors the children were making at the start of the trial was around 60 (a mean of 59.44, SD=39.91). After 12 weeks of using Play Attention this had dropped to around 50 (49.33, SD=26.06). This means children were getting better at controlling their impulsivity, a core symptom of ADHD. A child with impulse control problems will call out in class instead of raising their hand, be easily distracted, find it hard to sit still, have difficulty delaying gratification and may be aggressive. So being able to control their impulsivity can have enormous behavioural and social benefits for the child.

During our trial there was inevitably some variation in the amount of exposure each child had to the Play Attention system. Some games take longer than others, sometimes sessions had to be shorter because of lesson times and occasionally a child missed a session due to illness. So we looked carefully at our data to see whether the children who used the system more also benefitted more. It transpired that the more sessions the children had on the Play Attention system the larger were the reductions in impulsivity and reductions in response time variability (another measure of erratic behaviour). This 'dose relationship' is very reassuring. It suggests that more prolonged usage might result in even greater improvements for these children. Furthermore, when we analysed the data for the children according to their age, we found the beneficial effects were greater for the younger children (under ten years) than the older ones, which is a strong argument for starting early.

Other factors and future directions

One has to consider also the role of the child's home environment during the period of EEG biofeedback training at school. In one[^] controlled group study of EEG biofeedback training, a key factor that contributed to success was parenting style. Children whose parents used a systematic approach to parenting, with consistent reinforcement principles, had reduced primary symptoms of ADHD. Also, behavioural

improvement was maintained even in the absence of medication when parenting style was optimal. This means that this type of intervention will be more successful if backed up by parents who are committed to a behaviour modification programme based on positive reinforcement.

The fact that it can be used in the home is one advantage of the Play Attention system. It means parents can help to motivate their children to use it regularly and reward their progress with praise and approval. Motivation is critical to success, as better engagement with the games increases the likelihood of symptom improvement. Other studies have made use of a reward system⁶⁷ to reinforce the behavioural improvements, sometimes with points that could be exchanged for rewards. Since having a child with ADHD can be stressful for parents, successful interventions should also include strategies to support the parents and help them cope on a day-to-day basis. Research we have been conducting at the University of Hertfordshire with parents of children with special needs⁸ has found the Do Something Different approach extremely effective in reducing their stress levels. Therefore, a combination of EEG biofeedback and parental and educational support may be the way forward to finding a solution to ADHD that does not lie in a bottle of pills.

BOX OUT?

=====

Rose* has a 9 year old son Jack* with ADHD. He started using Play Attention 8 months ago and Rose believes it has helped him maintain longer episodes of attention, particularly with his schoolwork.

Jack uses Play Attention at home on three evenings each week. His parents sought help for him because he was struggling to concentrate at school and falling behind academically. Rose says, "Since using Play Attention his concentration levels have slowly improved and following a parent's evening last week we were informed by his Class Teacher that he has moved up two sub groups within Maths, which was the main topic he was struggling in. Obviously as parents this has been fantastic news in his achievements!"

The Consultant at the local hospital reduced Jack's medication three months ago because he was not gaining weight on a higher dose (suppression of appetite is one of the side affects of ADHD medication). As a result of him being on a lower dose of medication, his ability to concentrate for longer periods of time have reduced, however he does continue to remain reasonably focused when undertaking is Play Attention sessions on an evening at home.

Reflecting on using the system educationally, Rose commented, "We feel that Play Attention could and should be utilised within a school environment to support children with attention-related learning difficulties. We are 100% sure that Play Attention would be an excellent support tool for such children and it would also support eachers in managing children with such attention-related

learning difficulties. It's not only challenging, motivational and interesting for children to use but would also be an excellent tool that Teachers can track children's progress on."

*names changed for confidentiality, all other details are as reported.

References

- ¹ Biederman, J., Faraone, S., Milberger, S., Guite, J., Mick, E., Chen, L., et al. (1996). A prospective 4-year follow-up study of attention-deficit hyperactivity and related disorders. *Archives of General Psychiatry*, *53*, 437–446.
- ² Murphy, K., & Barkley, R. A. (1996). Attention deficit hyperactivity disorder adults: Comorbidities and adaptive impairments. *Comprehensive Psychiatry*, *37*, 393–401.
- ³ Greenhill, L. L., Halperin, J. M., & Abikoff, H. (1999). Stimulant medications. *Journal of the American Academy of Child and Adolescent Psychiatry*, *38*(5), 503–512.
- ⁴ Swanson, J. M., McBurnett, K., Christian, D. L., & Wigal, T. (1995). Stimulant medication and treatment of children with ADHD. In T. H. Ollendick & R. J. Prinz (Eds.), *Advances in clinical child psychology* (Vol. 17, pp. 265–322). New York: Plenum Press.
- ⁵ Pelham, W. E., & Murphy, H. H. (1986). Attention deficit and conduct disorder. In M. Hersen (Ed.), *Pharmacological and behavioral treatment: An integrative approach* (pp. 108–148). New York: Wiley.
- ⁶ Monastra, V. J. Lynn, S., Liden, M.Lubar, J. F., Gruzelier, J. & La Vaque, J. (2005). Electroencephalographic Biofeedback in the Treatment of Attention-Deficit/Hyperactivity Disorder. *Applied Psychophysiology and Biofeedback*, *Vol. 30*, No. 2, June 2005.
- ⁷ Lind Linden, M., Habib, T., & Radojevic, V. (1996). A controlled study of the effects of EEG biofeedback on cognition and behavior of children with attention deficit disorder and learning disabilities. *Biofeedback and Self-Regulation*, *21*(1), 35–49.
- ⁸ Sharma, S. Pine, K.J., & Fletcher, B. (C), (in submission). FIT-Do Something Different: An intervention to reduce parental stress and depression in mothers of children with autism.