# ATTENTION DEFICIT HYPERACTIVITY DISORDER AND EEG BIOFEEDBACK: A PILOT CASE STUDY IN FINLAND

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# TIIVISTELMÄ

Tämän tapaustutkimuksen tarkoituksena oli tutkia kuinka elektroenkefalografiaan (EEG) liitetyn biopalautteen avulla voidaan kuntouttaa tarkkaavaisuushäiriöistä kärsivää 9-vuotiasta poikaa. Biopalautekuntoutuskäyntejä oli kaksi kertaa viikossa yhteensä 40 kertaa ja harjoittelu kesti 4,5 kuukautta. Biopalautemetodin mukaan EEG-kuntouksen tavoitteena oli: vähentää kuntoutettavan theta-aaltoja (4-8 Hz), jotka liittyvät alentuneeseen tarkkaavuuteen ja päiväunelmointiin; vähentää lihasjännitettä (EMG-aktiviteettia) hyperaktiivisuuden hillitsemiseksi; lisätä sensorimotorisia aaltoja (12-15 Hz), jotka liittyvät motoristen liikkeiden estämiseen; lisätä beta-aaltoja (16-20 Hz), jotka liittyvät aktiiviseen tiedon prosessointiin. Aliaktivaatioteorian mukaan tarkkaavaisuushäiriö johtuu liian vähäisestä autonomisesta ja kortikaalisesta aktivaatiosta, ja oletuksena oli, että nostamalla tätä vireystilaa normaalimmalle tasolle EEG-biopalautteen avulla voidaan saada aikaan tarkkaavuuden paranemista. Tarkkaavaisuushäiriötä käsiteltiin vaikeutena mukauttaa käyttäytymistä tilanteen vaatimalla tavalla, ja ajateltiin, että EEG:ssa tapahtuvat muutokset olisivat tilannesidonnaisia (aktiivisen vs. passiivisen prosessoinnin tilanteet). Kuntoutettavan EEG:aa mitattiin koko ajan. Riippuvina muuttujina käytettiin tuloksia tietokonepohjaisesta tarkkaavaisuuden arviontiohjelmasta (ATTE), kognitiivisista kykytestauksista (WISC-R) ja kahdesta käyttäytymisen arviointilomakkeesta. Kuntoutettava onnistui alentamaan theta-aaltojaan ja jonkin verran lisäämään sensomotorisia ja beta-aaltojaan, mutta lihasjännityksen vähentäminen ei onnistunut. Vain sensomotoristen ja beta-aaltojen muutokset olivat tilannesidonnaisia. ATTE-pistemäärät osoittivat pidempikestoisen tarkkaavuuden, keskittymiskyvyn ja itsesäätelyn parantuneen. Muutokset kognitiivisten kykytestausten tuloksissa olivat pieniä, mutta pääsääntöisesti positiivisia. Arviointilomakkeiden perusteella kuntoutettavalla oli ongelmia yleistää oppimansa taidot jokapäiväiseen elämään. Tämä tapaustutkimus antoi tukea tarkkaavaisuushäiriön aliaktivaatioteorialle, koska EEG-aalloissa näkynyt lisääntynyt aktivaatio tuotti parempaa keskittymistä ATTE-arviointiohjelmalla mitattuna.

**Avainsanat:** aktivaatio, biopalaute, EEG, tarkkaavaisuushäiriö

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*Attention deficit hyperactivity disorder and EEG biofeedback: a pilot case study in Finland*

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## ABSTRACT

The present single case study was conducted to explore the electroencephalography (EEG) biofeedback (neurofeedback) method in alleviating the symptoms of attention deficit hyperactivity disorder (ADHD) of a 9-year-old boy. The neurofeedback training lasted for 4.5 months, containing 40 biweekly sessions. According to the paradigm, the aim of the training was to teach the subject to decrease theta (4-8 Hz) waves, associated with decreased attention and daydreaming; to decrease electromyographic (EMG) activity to reduce hyperactive behavior; to increase sensorimotor rhythm (SMR, 12-15 Hz) waves, associated with motor inhibition; and to increase beta (16-20 Hz) waves, associated with active information processing. It is hypothesized that ADHD is caused by autonomic and cortical underarousal, and by raising the arousal to more normal levels via neurofeedback the condition can be alleviated. ADHD was seen as a motivational deficiency in adjusting one's behavior to the demands of the situation, and it was hypothesized that EEG changes would be situation dependent (active vs. passive processing situations). The subject's EEG readings were measured along with the following dependent variables: ATTE computerized attention assessment scores, Wechsler Intelligence Scale for Children Revised (WISC-R) scores and two behavior rating scales. The subject achieved to lower his theta waves and slightly increase his SMR and beta waves, but EMG training was not successful. Only SMR and beta changes were situation dependent. ATTE scores indicated enhanced sustained attention, ability to concentrate and self-control. WISC-R changes were small but mostly positive, while behavior ratings indicated problems in generalizing learned skills to everyday life outside the training context. The present case study supported the underarousal hypothesis of ADHD in that increased arousal reflected in EEG readings produced better attention measured with ATTE variables.

**Key words:** ADHD, arousal, biofeedback, EEG, neurofeedback

# INTRODUCTION

Attention problems and hyperactive behavior of children and adolescents have become more and more widespread in classrooms in Finland. They are the most common reason along with learning difficulties for children to be referred to communal family counseling clinics. Traditionally, after a diagnosis of attentional deficit, the treatment plan has been purely behavioral: children are put to special classrooms and sometimes behavioral contingencies are used. Medication therapies to treat attentional deficits are very rarely used in Finland, which makes the situation in the country very different compared to the United States where psychostimulant medication, usually methylphenidate, dextroamphetamine or pemoline, is the treatment of choice in most cases of attention deficit syndromes. However, medication therapy has many drawbacks. The most important shortcoming is that the effect lasts only as long as medication is continued. Also, there are other possible side effects like decreased appetite, insomnia, anxiety, irritability, stomach aches and headaches. Thus in the United States, efforts to find alternative treatments have been actively searched since mid 1970s. EEG biofeedback is one of the most studied treatment options and it has become widely practised as a possible alternative for stimulant medication. In Finland, where behavioral interventions and special education have been virtually the only treatments available, EEG biofeedback could be an alternative approach for alleviating the symptoms of attentionally disordered children and adolescents if its efficacy could be reliably proved.

The concept of attention deficit has evolved over the decades from the brain damaged child to minimal brain dysfunction (MBD); to hyperactive child syndrome in the 1960s: to attention deficit disorder (ADD) in 1980s and finally, the latest version of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV, APA, 1994) calls it attention deficit/hyperactivity disorder (ADHD) and divides it into three subtypes. The subtypes are a predominantly inattentive type of ADHD, a predominantly hyperactive-impulsive type of ADHD and a combined type of ADHD. For the purposes of the present paper, the concept attention deficit disorder, from now on ADD, will be used as a substitute for DSM-IV's term ADHD when talking about the disorder in general. When referring to its subtypes, the predominantly inattentive type will be marked as ADD/-H and the predominantly hyperactive-impulsive type as ADD/+H. Where not differentiated or where talking about the combined type, ADD alone will be used.

According to Barkley (1990), primary symptoms of ADD are inattention, impulsivity, hyperactivity, deficient rule-governed behavior and greater variability of task performance. Diagnosing the condition is a long process and usually involves clinical interviews, pediatric medical examination, evaluating the patient with behavior rating scales, tests and possibly observational methods. Nonetheless, a detailed differential diagnosis into a specific subtype helps in planning the treatment, whatever type of treatment it is, and in predicting the outcome.

ADD children differ from normal children of same age in their EEG profiles and their event-related potentials (ERPs). Routine EEG screening is not enough to show the differences in ADD children's EEG patterns (Phillips, Drake, Hietter, Andrews & Bogner 1993) but they can be detected using more specific measures like quantitative EEGs and brain imaging. One of the differences concerns theta waves (4-8 Hz) which occur in drowsiness and are associated with decreased attention and daydreaming. In Gale's (1977) vigilance study greater amounts of theta occurred in persons performing poorly. ADD patients have excess theta in their EEGs both at baseline and during cognitive tasks (Janzen, Graap, Stephanson, Marshall & Fitzsimmons 1995; Lubar, Swartwood, Swartwood & Timmermann 1995; Mann, Lubar, Zimmerman, Miller & Muenchen 1992; Matsuura, Okubo, Toru, Kojima, He, Hou, Shen & Lee 1993; Suffin & Hamlin 1995). Another, although more controversial difference, concerns alpha waves (8-13 Hz) which are seen when individual's eyes are closed and under conditions of physical relaxation and relative mental inactivity (Duffy, Iyer & Surwillo, 1989). Matsuura et al. (1993) found that an ADD group had fewer alpha while Suffin & Hamlin (1995) discovered excess alpha in their ADD group. Finally, beta waves (13 Hz and over) mark mental and physical activity and increased concentration and information processing. Decrease in beta seems to be characteristic to both ADD/+H children (Lubar et al. 1995; Matsuura et al. 1993) and ADD/-H children (Mann et al. 1992). In addition, ADD/-H patients' theta excess was particularly evident at frontal locations, while beta deficiency was more pronounced at temporal locations (Mann et al. 1992). Lubar et al. (1995) found that ADD children's theta/beta ratios differed most from those of controls' at central locations along the midline.

When it comes to ERPs, not many studies have included ADD patients; the focus has usually been on children with learning disabilities (eg. Lubar, Douglas, Gross, Shively & Mann, 1990). However, Lubar, Mann, Gross & Shively (1992) investigated gifted children, normal children and children with learning disabilities with ADD/-H and found that the P3 component, believed to represent the interpretation of stimulus meaning, was less positive in the latter group. In addition, Lubar et al. (1995) present an ERP habituation study with ADD/+H boys. They found that in a repeated stimulus situation (listening to repetitive tones) the hyperactive group showed a decrease in amplitude for all ERP components thus showing habituation, while the control group did not.

As turning to operant conditioning of the EEG, EEG biofeedback or neurofeedback, "the presentation of a stimulus or a reward is contingent on the production of a particular EEG pattern by the subject" (Andreassi, 1989, 64). Neurofeedback has been used to alleviate many different conditions, for example epilepsy, migraine headaches, anxiety and ADD. Neurophysiological basis for neurofeedback in treating ADD is suggested by Abarbanel (1995) in that neural networks mediating attention processes can be adjusted through neuromodulation and stabilized through long term potentiation (LTP). He also suggests that attentional disorders represent coarseness in the limbic control of attentional processes, which can be fine tuned in neurofeedback training.

As a theoretical basis for neurofeedback in treating ADD, the present paper will use the underarousal hypothesis of ADD. According to this view first presented by Satterfield & Dawson (1971), the increased amount of motor activity in ADD patients is secondary to lowered levels of reticular activating system excitation, and represents the patient's attempt to increase his proprioceptive and exteroceptive sensory input. In other words, ADD patient's physiological arousal does not correlate with his/her behavioral arousal, or activity level; thus hyperactive children are considered to be deficient in cortical and autonomic arousal while being excessively active behaviorally (Rosenthal & Allen, 1978). In a recent review article, Kondo (1996) concludes that in addition to dysfunctions of subcortical structures involved with arousal, also those of the frontal lobe give rise to attention deficit disorder.

In neurofeedback training, the rationale for attenuating the symptoms of ADD is based on the underarousal hypothesis: via learning to reduce theta waves, associated with low cortical arousal and to increase beta and/or sensorimotor rhythm (SMR) waves, associated with higher cortical arousal and inhibition of involuntary motor activity, respectively, it is possible to normalize the EEG pattern of ADD patients and thus reduce the behavioral symptoms. Also, electromyography conditioning can be used to decrease hyperactivity in conjunction with EEG biofeedback (see below).

Neurofeedback paradigm has been successfully used in different situations: Beatty, Greenberg, Deibler & Hanlon (1974) taught a group to augment theta waves and another to augment beta in a vigilance study; Sterman (1984) treated epilepsy patients; McFarland, Neat, Read & Wolpaw (1991) taught individuals to move a cursor on a screen both one-dimensionally and in their later study two-dimensionally (Wolpaw & McFarland, 1994). For treating ADD, Dr. Lubar's work for the past 20 years has been guiding the procedure of the present study. He combined SMR training to manage seizures with EEG biofeedback of beta training and theta inhibition (Lubar, 1991).

There have been numerous studies to assess the effectiveness of neurofeedback training for treating ADD. Tansey (1993) reports ten-year stability for the results of SMR neurofeedback training conducted on a 10-year-old learning disabled and hyperactive boy. His later study (Tansey, 1991) contained a group of learning disabled children who received SMR training and whose EEG signatures normalized and Wechsler Intelligence Scale for Children - Revised (WISC-R) scores significantly improved as a result. Rossiter and LaVaque (1995) compared the effects of neurofeedback and psychostimulants in treating ADD/+H and found that both the feedback group and the medication group improved on Test of Variables of Attention (TOVA) measures of inattention, impulsivity, information processing and variability at post-treatment. Lubar et al. (1995) evaluated the effectiveness of neurofeedback training for ADD/+H children in a clinical setting. They measured changes in TOVA scores, behavioral ratings and WISC-R performance. The subjects who successfully decreased theta activity (12 out of 21) showed significant improvement in TOVA performance. Parent ratings of behavior improved for all subjects. WISC-R scores of successful theta decrease children improved significantly. Also Linden, Habib & Radojevic (1995) demonstrated the effectiveness of neurofeedback training in treating ADD/+H and ADD/-H children. They had a control group of children on a waiting list. After 40 sessions of training, the ADD group showed a significant improvement in IQ scores of Kaufman Brief Intelligence Test compared to the controls.

In addition to EEG biofeedback, electromyography (EMG) feedback is a common component in neurofeedback training for ADD. EMG measures and records electrical potentials associated with contractions of muscle fibers and its operant conditioning is useful in controlling hyperactivity which is manifested by fidgeting and constant muscle movements. EMG biofeedback combined with relaxation training was successfully applied in treating hyperactive boys (Braud, Lupin & Braud, 1975; Denkowski, Denkowski & Omizo, 1983). However, according to Sperry's principle, the entire output of our thinking mechanism goes into the motor system. Consequentially, it appears that the level of involvement (Malmo, 1975) and task difficulty (Svebak, Dalen & Storfjell, 1981) can affect EMG activity raising it; thus motivation and effort clearly raise EMG levels. Malmo (1975) states that listening attentively to a story usually results in EMG gradients appearing in recordings from the forehead muscles, which is exactly one of the feedback conditions in the present case study. Thus it might be questionable if EMG training attached to EEG biofeedback with listening condition is useful because the latter requires concentration and involvement and thus raises EMG levels which at the same time should be diminished. However, since the electrodes in the present study were not placed in the forehead area, the present EMG readings have a slightly different meaning.

Aside from EEG biofeedback, Kotwal, Burns & Montgomery (1996) present a case study on the effects of computer-assisted cognitive training in alleviating ADD symptoms. They used a Captain's Log computer program designed to help develop attention and concentration, among other learning skills. Brain wave patterns were recorded only pre and post-treatment. Their subject's EMG levels clearly decreased, and both theta and beta amplitudes showed a reduction. The latter finding is somewhat unexpected because the usual paradigm in EEG neurofeedback with ADD is to decrease theta and increase beta. The most significant behavior change with the subject was the increase in on-task behaviors and reduction in disruptive behaviors at school.

The present single case study was conducted to explore the neurofeedback method for the first time in Finland in treating a nine-year-old attention deficit disordered hyperactive boy. The paradigm was to decrease theta waves and EMG while increasing first SMR and then beta waves in order to enhance his concentration and reduce restlessness and fidgeting. The aim of the present study was to investigate the neurofeedback training process in more detail than the studies reviewed: besides the system's feedback situations, the EEG rewards and readings were monitored also during baselines and video game -like situations, while previous studies have not made such distinctions within the training sessions.

In line with Barkley's (1990) view, ADD is considered here more as a motivational deficiency than an attentional deficiency, because of the immense situational fluctuation of the behavioral symptoms and the strong effect that encouragement has on ADD children's achievements. Due to the view of ADD as a difficulty to control one's behavior according to the needs of the situation, the hypothesis is that theta, SMR and beta training should yield different results in different situations during training sessions. After successful neurofeedback training, the subject's theta levels should go down and his SMR and beta levels up during active cognitive processing. These changes, however, should not be as significant during passive baseline situations. It can be expected that the EEG differences between the situations of active cognitive processing and passive baseline would become larger after successful neurofeedback training.

# METHOD

## Subject

The subject was J. K., a nine-year-old elementary school boy who had been referred to Niilo Mäki Institute clinic for learning disabilities from the family counseling clinic of his communal social and health care system. He was on 3rd grade when he came to neuropsychological evaluation to Niilo Mäki Institute. In the evaluation, no specific learning disabilities were found, J. K.'s problems seemed to be more in the areas of sustaining and dividing attention and the lack of memory strategies that would help him in learning new verbal material. His attentional problems had been noticed at school and also at home where he was restless, hyperactive and could not concentrate on his school work. He had problems with his class mates because he behaved disruptively in class. His teacher described him as being active in class discussions but not being able to do assignments silently without someone watching over. He also had a hard time staying on his seat during classes. J. K. was attending weekly special education lessons. He had never been on medication for his ADD as stimulants are very rarely used in Finland in treating ADD.

As diagnosing children with DMS-IV labels is not a standard procedure at the Niilo Mäki Institute, J. K. did not have a diagnosis given by a physician. However, he could reliably be classified as having the hyperactive type of attention deficit disorder based on professional psychological evaluations and Child Attention Problems scale (CAP, created by C. S. Edelbrock, in Barkley, 1990).

During the four and a half month period when J. K. attended biweekly neurofeedback sessions, his behavior was usually highly cooperative, he enjoyed the attention given to him and was eager to get praise. He learned the procedure quickly and understood what the purpose of our sessions was. No disruptive behavior occurred during the sessions.

## Instruments

### Physiological measures

EEG was recorded and feedback conditions carried out all through the 40 neurofeedback training sessions using the A620 EEG/neurofeedback system interfaced with a 386 tabletop microcomputer. A620 EEG/neurofeedback equipment were calibrated before training began and remained in calibration throughout the training. The following physiological measures were recorded: beta or SMR activity defined as 16-20 Hz or 12-15 Hz events above threshold level occurring in the absence of theta (4-8 Hz) events; and EMG activity defined as 50-150 Hz activity above threshold recorded from the EEG electrodes. The subject's EEG was sampled at a rate of 128 samples/second. The equipment uses Root-Mean-Squared values of EEG wave forms' microvoltages for its internal computations.

For the first block of 20 sessions, the EEG recordings were obtained from monopolar electrode site at C3 (J. F. Lubar, personal communication, December, 1996), referenced to the right ear and grounded to the left ear to increase SMR while decreasing theta and EMG; for the second block of 20 sessions, bipolar recording was used at electrode sites situated on the midline halfway between Cz and Pz and halfway between Fz and Cz, grounded to the left ear. Electrode sites were prepared with Omni-prep, and the electrodes were attached with Ten20 Conductive EEG Paste with impedance having to be below 7 kilohms.

Reward criteria were set so that 50 sampled events occurring in .5 second were required in order to receive a reward. An event occurs every time all three training criteria are being met simultaneously: when reward EEG activity is above the threshold, inhibit EEG activity is below the threshold and EMG activity is below the threshold.

Thresholds for EEG inhibit, EEG reward and muscle inhibit levels in peak-to-peak microvolts were set according to two pre-treatment recordings, both of which constituted of a 2-minute baseline and a 2-minute feedback. During these two pre-treatment recordings, the subject's EEG readings were monitored and the thresholds were set according to empirical criteria based on the readings in two of the equipment's displays.

First, the clinician's screen display shows different EEG readings: raw EEG, reward frequency, inhibit frequency, inhibit EEG, event & reward, raw EMG and inhibit EMG. These readings can be monitored to find out on what levels inhibit and reward frequencies oscillate and how often rewards are obtained. Second, the bar graph display indicates the microvolt levels and the thresholds of EEG reward, EEG inhibit and EMG inhibit, and shows the percentages above threshold for the three training parameters, as well as a count of the patient's score (A620 EEG Owner's Manual, 1996). According to Lubar (personal communication, February, 1997), thresholds are set with the help of the bar graph display, in which the percentage of inhibit should be between 50 and 70%, the percentage of reward between 30 and 50% and the percentage of EMG inhibit less than 20%. These directions were followed in the process of finding the suitable thresholds at 4.00 microvolts for SMR reward, 15.00 microvolts for theta inhibit and 14.00 microvolts for EMG inhibit and after session 20, 4.00 for beta reward. The threshold for EMG inhibit was set according to Lubar's (personal communication, December, 1996) suggestion. After setting the thresholds according to the aforementioned empirical criteria, the number of rewards per minute during feedback conditions was monitored throughout training. The number of rewards per minute during feedback conditions can theoretically be anything from 0 to 120. In the present study, the number of rewards increased during training but not enough to initiate changing threshold levels. Rewards gained did not exceed the amount of 25 per minute (Lubar et al., 1995), thus the threshold levels remained unchanged throughout training.

## Dependent variables

The effect of the neurofeedback training was assessed using a video game -like computerized attention assessment program linked to the neurofeedback sessions. Outside the sessions the subject was tested with WISC-R IQ tests and evaluated with self-control rating scales by parents and attention rating scales by his teacher. The expected change resulting from neurofeedback training is the increase in the difference between a situation in which the task given to the child requires active cognitive processing and a situation which represents passive baseline conditions.

**ATTE computerized attention assessment program**. ATTE is a computerized method for assessing the specific components of attention (Lyytinen, 1996). It resembles a video game in which the subject's task is to catch drops of different colors and sizes according to the color of the collecting can. Each session, the subject played ATTE game 2 times for 2 minutes, altogether four games per session. While playing the game, the following features of an individual's attention capacity are assessed: ability to sustain attention, concentrate on a task, select input, act in a non-impulsive manner and continue the task in spite of distractions. Also, the program tries to find out a possible reward dysfunction. According to Melto (1996), the most reliable variables are the ones to assess sustained attention (ATTE variable "impulsiveness"), the ability to concentrate (ATTE variable "amount of liquid") and self-control (ATTE variable "efficiency"), which will also be the ones used in the present study.

**Wechsler Intelligence Scale for Children Revised**. The subject was assessed pre and post-treatment with ten subtests (Information, Similarities, Arithmetics, Vocabulary, Comprehension, Picture Completion, Picture Arrangement, Block Design, Object Assembly and Coding) from the Wechsler Intelligence Scale for Children Revised (Wechsler, 1974). The pretreatment assessment was done at the family counseling clinic a year before the post-treatment assessment, so the time period was ideal because there is a test-retest practice effect if the two administrations occur less than six months apart.

**Self-control rating scale**. The present self-control rating scale was originally designed for teachers but as it is a clear 15 question questionnaire whose items apply well to home situations also, it was decided to have it filled out by the subject's parents pre and post-treatment and also during training after every ten sessions. Humphrey (1982) developed the scale to measure children's behavior and self-control in classroom. The Teacher's Self-Control Rating Scale (TSCRS) consists of 15 items reflecting a cognitive-behavioral conceptualization of self-control. The scale is divided in two: ten of the questions measure cognitive/personal self-control and five of the questions behavioral/interpersonal self-control (see Appendix 1 for the questionnaire form).

**Teachers' rating scale for attention problems**. Jokinen (1996) developed a questionnaire based on DSM-IV classification of ADDs and ATTE variables for teachers to assess the severity of attentional problems and the different components of attention (see Appendix 2 for the questionnaire form). The questionnaire was validated on 79 primary and secondary school pupils (grades 1 through 8) of which 41 were in normal and 38 in special education classes. Internal reliability in sections measuring different components of attention, measured with Cronbach alpha, differed from 0.8999 to 0.965, which means that the scale was reliable. There is a total of 37 questions in the questionnaire, 4-10 questions tapping to each six components of attention. The components of attention measured are:

1. Sustained attention
2. Selectivity of attention
3. Flexibility
4. Distractability
5. Sensitivity to reinforcement
6. Impulsiveness and hyperactivity

The questionnaire was filled out by the subject's teacher pre and post-treatment and after 4 and 12 weeks of training.

## Procedure

The subject attended neurofeedback training twice a week for 4.5 months from May to mid-September 1997. He went through a total of 40 sessions, each session lasting approximately an hour and ten minutes. The training was divided into two 20 session blocks: in the first block the goal was to increase SMR and decrease theta and EMG artifact; in the second block the aim was to increase beta and decrease theta and EMG artifact. Thus the first block concentrated more on reducing hyperactivity, while in the second block the purpose was to enhance the subject's active information processing and concentration. Each biweekly session consisted of 10 conditions: four baseline conditions, two ATTE game conditions and four feedback conditions in the following order:

1. 2-minute baseline
2. 4.5 minutes of playing ATTE game without feedback
3. 2-minute baseline
4. 5 minutes of feedback game with visual and auditory feedback
5. 5 minutes of the subject reading with auditory feedback
6. 2-minute baseline
7. 5 minutes of feedback game with visual and auditory feedback
8. 5 minutes of the subject listening to reading with visual and auditory feedback
9. 2-minute baseline
10. 4.5 minutes of playing ATTE game without feedback

In baseline conditions, the computer screens were black and the subject sat in a comfortable chair in front of the screen. He was told to sit still and relax. There were two computer screens, one for ATTE game and one for neurofeedback software. In ATTE conditions, the subject played the game on one screen while the feedback computer screen was black and no EEG feedback was given. In feedback conditions 4 and 7, the subject played feedback games provided in the A620 EEG/Neurofeedback software package: the bar graph display (see above) was used in condition 4 and other feedback games in condition 7. The games constitute of an interactive visual display, for example a color wheel in which the colors advance around the periphery with each reward criterion reached, and a puzzle display in which the pieces go to their right places to form a picture with each reward criterion reached. In feedback condition 5, the subject read passages from a children's novel and at the same time listened to auditory feedback, the computer screen was black. In condition 8, the therapist read aloud the same children's novel and the subject listened to it and at the same time watched the bar graph display and listened to auditory feedback.

EEG data and ATTE measures were recorded every session. WISC-R was administered pre and post-treatment. The questionnaires were filled by J. K.'s parents five times and his teacher four times during the training period of 4.5 months.

# RESULTS

## Learning to benefit from the neurofeedback

J. K. learned to increase his scores throughout the training. The neurofeedback software counts rewards with a running score counter in all feedback conditions, and ATTE game counts scores in ATTE conditions. Two separate scoreboards on paper were kept: one for feedback scores and one for ATTE scores. Two best scores of feedback conditions and ATTE conditions of that particular session were written up on the boards at the end of each session. The scoreboards were very effective in keeping up J. K.'s motivation and long-term effort. In feedback conditions, the subject learned to associate feedback tones and developments in visual displays with rising scores and learned to control his EEG in order to score higher. Figure 1 shows the development of the subject's average feedback scores (rewards per minute) as a time series graph.

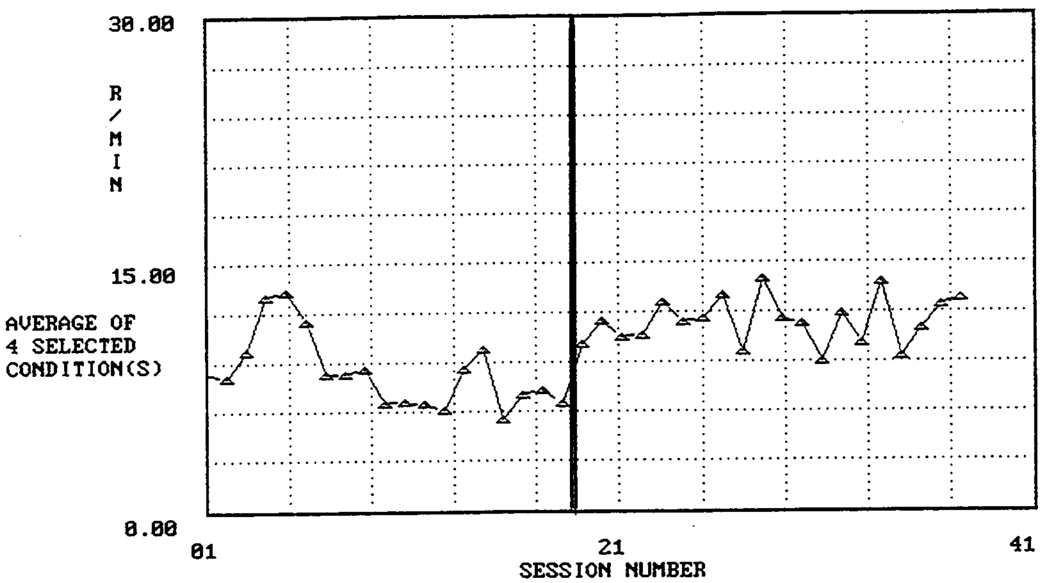


FIGURE 1. The development of J. K.'s scores of feedback sessions (rewards per minute). The scores (rewards per minute) from each session were averaged together. Vertical line divides the two training blocks.

## Physiological data: EEG and EMG readings

The 40 sessions of the present neurofeedback training program were divided in two 20-session blocks. In the first block (sessions 1 to 20), SMR/theta paradigm was used and the aim was to increase SMR waves of 12-15 Hz and decrease theta waves of 4-7 Hz while also trying to decrease EMG (50-150 Hz) extracted from the EEG electrodes. In the second block (sessions 21 to 40), beta/theta paradigm was used and the aim was to increase beta waves of 16-20 Hz and continue decreasing theta waves of 4-7 Hz while still trying to decrease EMG.

As can be seen in all EEG data time series graphs (Figures 1, 4, 5, 7 and 8), there is a measurement error at session 3, which causes the very steep downward curve in the data.

### The first block of 20 sessions: SMR/theta paradigm

During the first phase of J. K.'s neurofeedback training of increasing SMR, decreasing theta and EMG, the SMR increase was not big and nor was the theta decrease. EMG fluctuated greatly. At session 1, average theta level of baseline conditions was 19.44 microvolts; of ATTE conditions 19.50 microvolts; and of feedback conditions 20.84 microvolts. After going lower, the theta levels came back up to slightly higher than session 1 levels (see Figures 5, 6, 7 and 8). At the end of the first block at session 20, the average theta level of baseline conditions was 19.85 microvolts; of ATTE conditions 21.86 microvolts; and of feedback conditions 22.09 microvolts.

At session 1, the average SMR level of baseline conditions was 8.20 microvolts; of ATTE conditions 7.06 microvolts; and of feedback conditions 8.39 microvolts. Contrary to what was expected, SMR levels decreased along with theta levels (compare Figures 4 and 5). However, after the slight decline, SMR levels of feedback and ATTE conditions rose to slightly higher than the session 1 levels at session 20: the average of ATTE conditions to 8.83 microvolts and the average of feedback conditions to 8.44 microvolts. The average of baseline conditions deteriorated to 8.02 microvolts (see Figure 2).

EMG readings varied considerably more than the EEG readings. At session 1, the average EMG level of baseline conditions was 7.80 microvolts; of ATTE conditions 9.01

microvolts; and of feedback conditions 8.07 microvolts. At session 20, the average EMG level of baseline conditions was 11.21 microvolts; of ATTE conditions 17.45 microvolts; and of feedback conditions 11.97 microvolts. Thus at session 20 EMG levels were much higher than the session 1 levels, but J. K. was highly hyperactive and fidgety the day of the 20th session, so this finding is not representative of his continuous EMG recordings. Overall, he did not seem to learn to successfully reduce his EMG activity during training, and it seemed that baseline conditions yielded the lowest EMG readings.

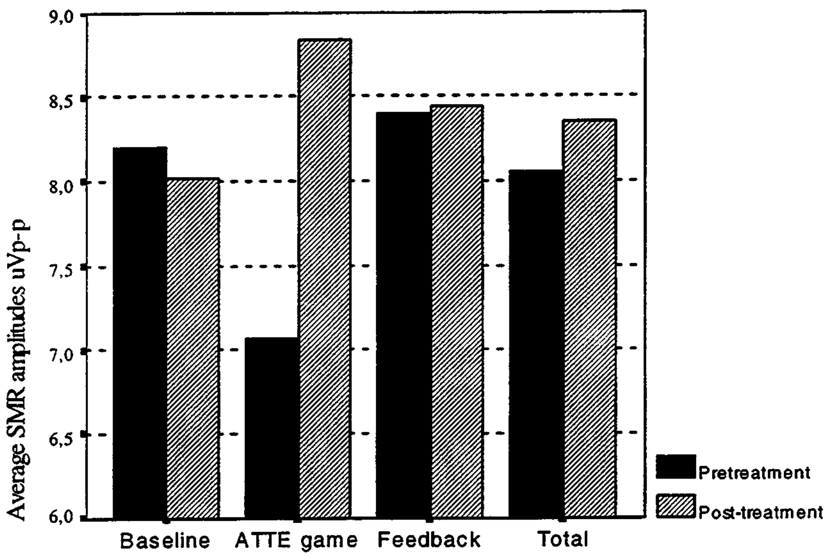


FIGURE 2. Change in SMR amplitudes from session 1 to 20 during different conditions.

## The second block of 20 sessions: beta/theta paradigm

During the second block of the training of increasing beta, decreasing theta and EMG, the changes in EEG readings were clearer than those of the first block. At session 21, the average theta level of baseline conditions was 18.29 microvolts; of ATTE conditions 15.23 microvolts; and of feedback conditions 17.64 microvolts. Then theta levels went down during the whole beta/theta paradigm block. At session 40 they were the following: the average of baseline conditions 15.00 microvolts; of ATTE conditions 14.94

microvolts; and of feedback conditions 16.33 microvolts. Figures 5, 6, 7 and 8 show the development of theta waves.

Beta levels changed slightly but in a different way than theta levels during this second block. At session 21, the average beta level of baseline conditions was 4.86 microvolts; of ATTE conditions 4.51 microvolts; and of feedback conditions 4.89 microvolts. At session 40, the average beta of baseline conditions was 4.67 microvolts; of ATTE conditions 4.79 microvolts; and of feedback conditions 4.94 microvolts. Since the aim was to increase beta, there was a slight deterioration in baselines but an increase in ATTE and feedback conditions. Figures 3 and 4 show the development of beta waves.

EMG levels could not be evaluated because they went very low due to changed electrode placement during the beta/theta paradigm training.

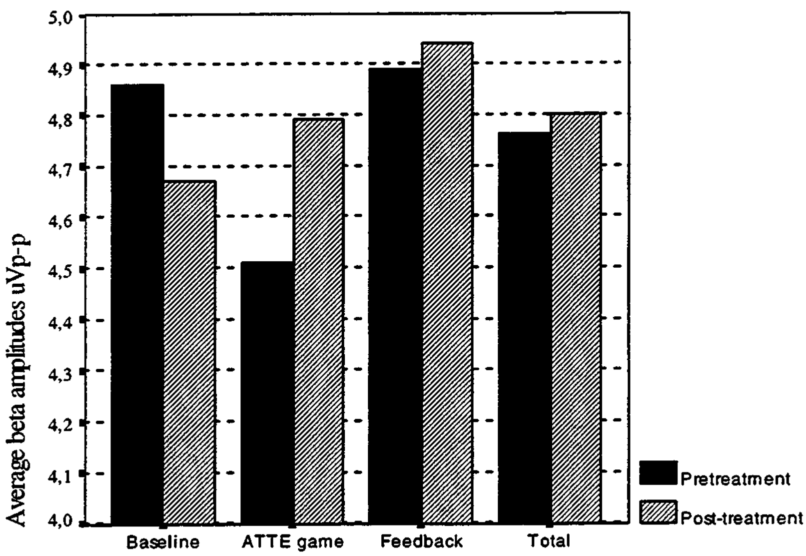


FIGURE 3. Change in average beta amplitudes from session 21 to 40 during different conditions.

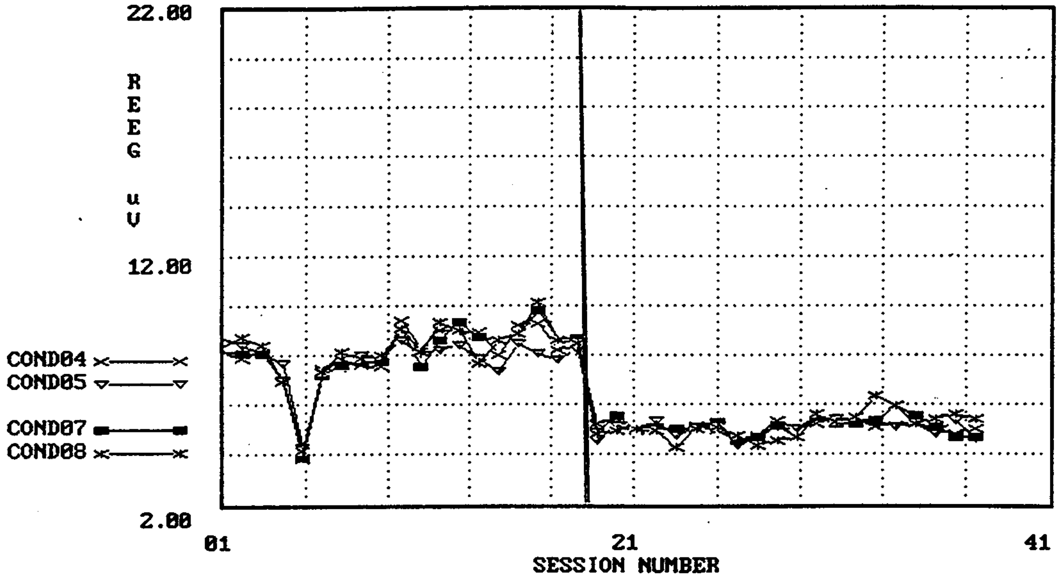


FIGURE 4. SMR and beta amplitudes during feedback conditions from session 1 to 40. Vertical line divides the first block of 20 sessions of SMR and the second block of 20 sessions of beta. (cond04 = game with auditory and visual feedback, cond05 = subject reading with auditory feedback, cond07 = game with auditory and visual feedback, cond08 = subject listening with auditory and visual feedback)

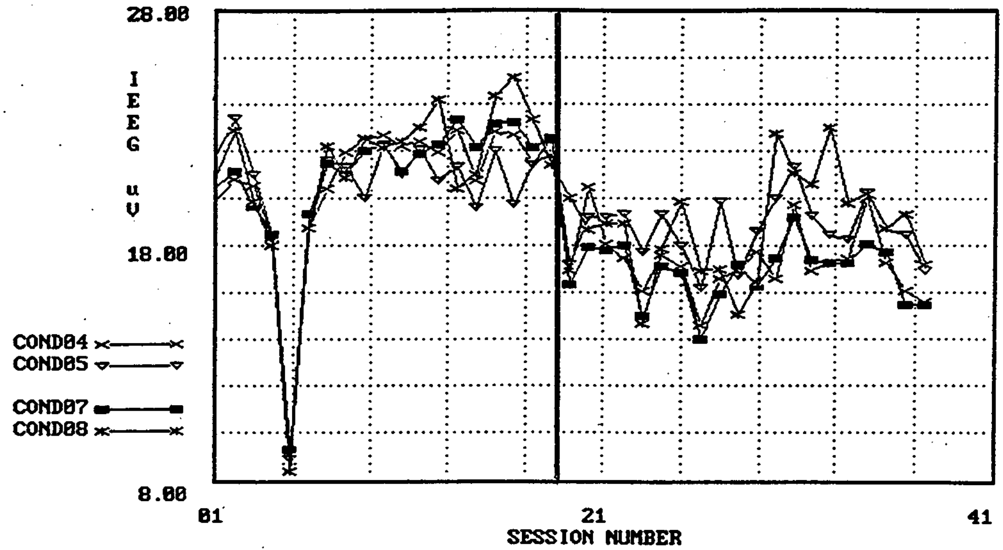


FIGURE 5. Theta amplitudes during feedback conditions from session 1 to 40. Vertical line divides the two training blocks. (cond04 = game with auditory and visual feedback, cond05 = subject reading with auditory feedback, cond07 = game with auditory and visual feedback, cond08 = subject listening with auditory and visual feedback)

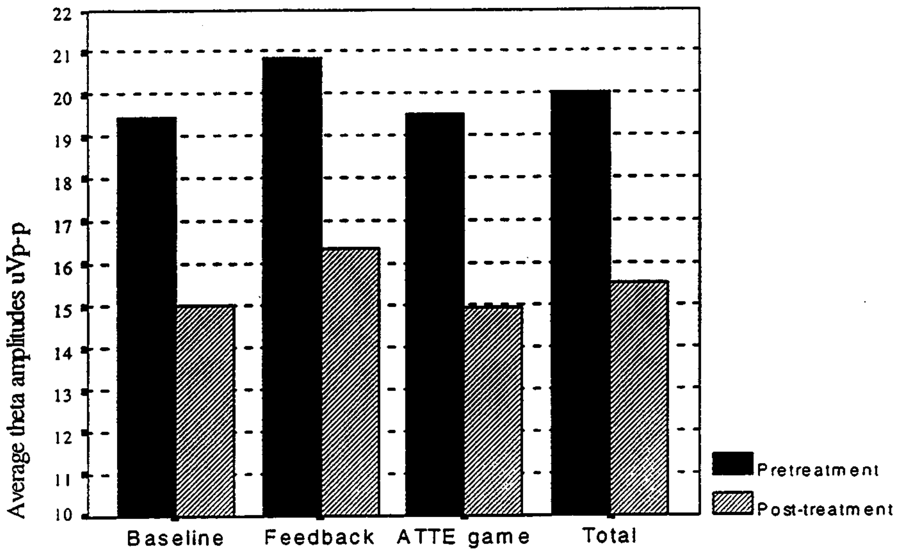


FIGURE 6. Change in average theta amplitudes from session 1 to 40 during different conditions.

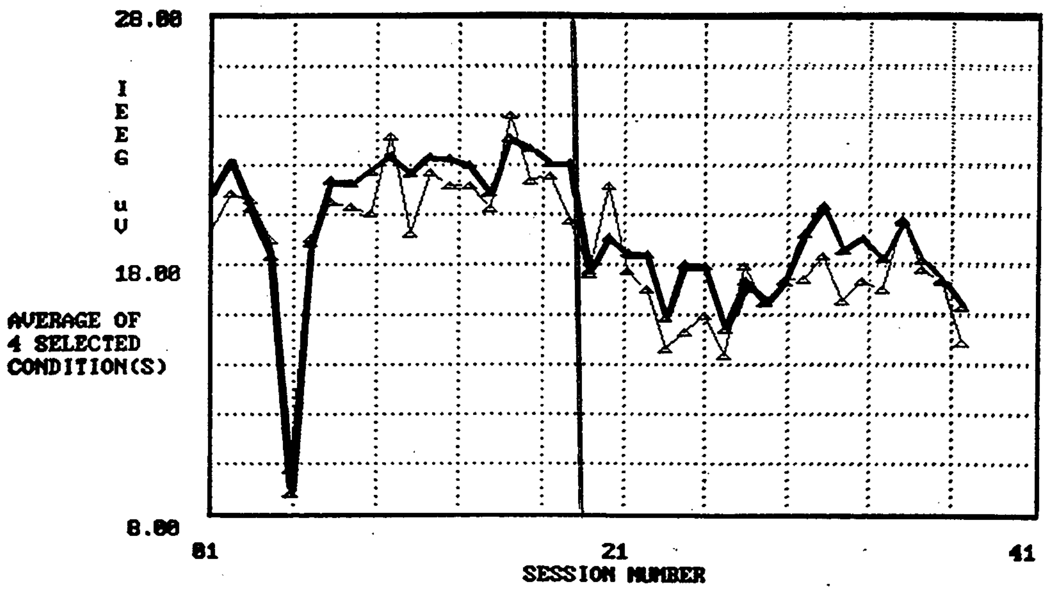


FIGURE 7. Average theta amplitudes of feedback conditions compared to average theta amplitudes of baseline conditions from session 1 to 40. Darker graph is the feedback graph. Vertical line divides the two training blocks.


FIGURE 8. Average theta amplitudes of feedback conditions compared to average theta amplitudes of ATTE conditions from session 1 to 40. Darker graph is the feedback graph. Vertical line divides the two training blocks.

## Behavioral data: ATTE and WISC-R

**ATTE computerized attention assessment program.** The subject played ATTE game four times every session: two 2-minute games in condition 2 and two 2-minute games in condition 10. In total, J. K. played 160 games of which 140 are included in the time series data. While playing the game, his EEG was measured but no EEG contingent feedback was given. J. K.'s score got better all the time and his score table was an efficient motivator for him. More importantly, his sustained attention, ability to concentrate and self-control gradually and continuously improved measured by ATTE variables impulsiveness, amount of liquid and efficiency, respectively (Figures 9, 10 and 11).

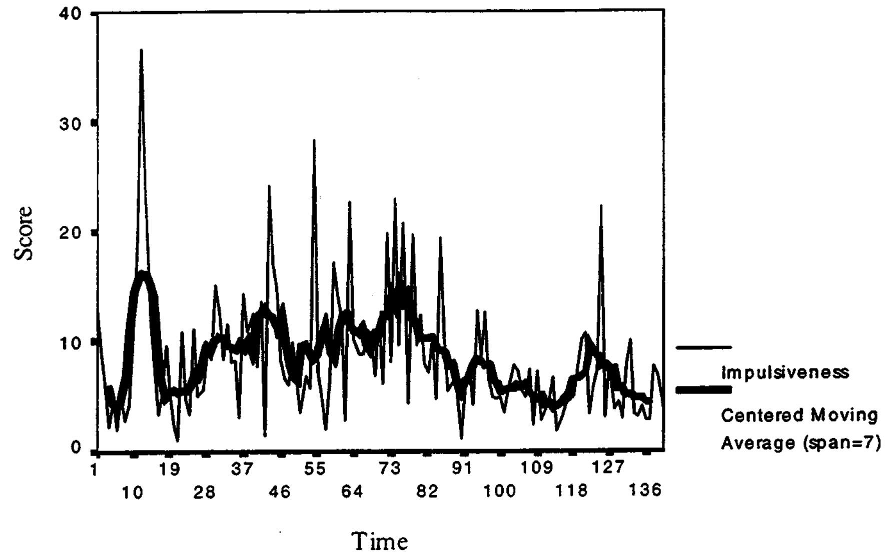


FIGURE 9. The development of impulsiveness scores measured by ATTE attention assessment program. Centered moving average graph shows a downward trend in impulsiveness, and thus an increase in sustained attention.

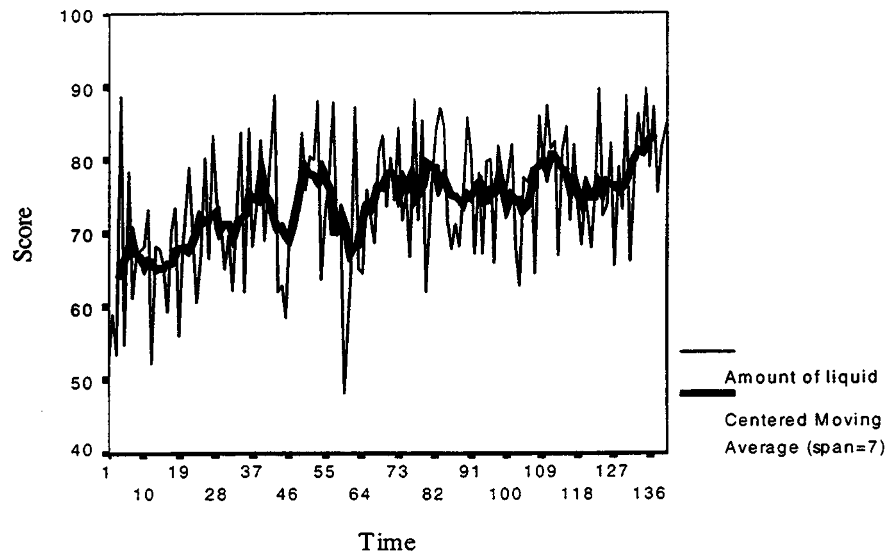


FIGURE 10. The development of amount of liquid scores measured by ATTE attention assessment program. Centered moving average graph shows a continuous upward trend in ability to concentrate, which the amount of liquid score reflects.

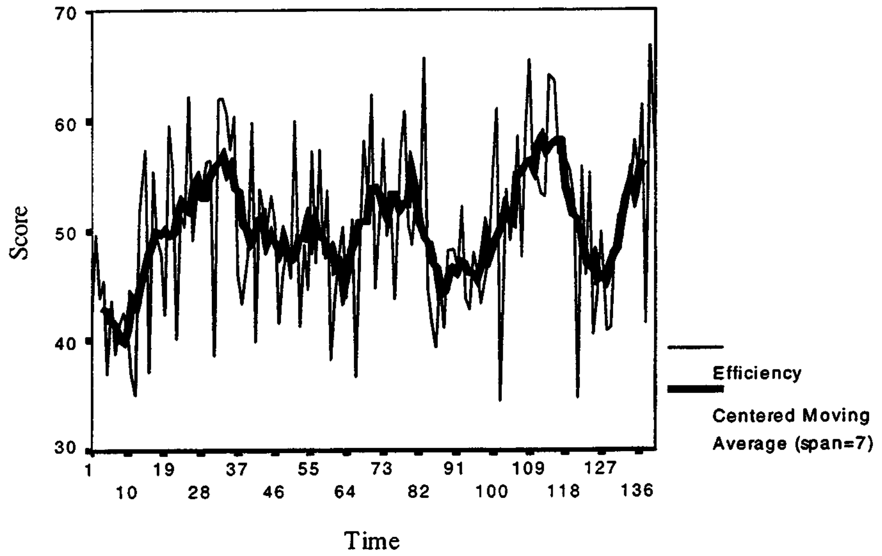


FIGURE 11. The development of efficiency scores measured by ATTE attention assessment program. Centered moving average graph shows an upward trend in the scores, which represents the subject's improving self-control.

**Wechsler Intelligence Scale for Children Revised**. In the WISC-R ability test (Wechsler, 1974), J. K. showed significant improvement (> 3 units) in the performance section of the test, his IQ score going up from 95 to 101. The verbal section stayed the same, at IQ 103. The overall IQ went slightly up from 100 to 102. The subject's WISC-R profile changed somewhat during the year in between testings (see Figure 12). There were two significant improvements (change > 3 units) in J. K.'s subtest scores. In the performance section, there was a four unit achievement score improvement in the Block Design subtest in the second testing. In the verbal section, the clearest difference from the first testing was another four unit achievement score improvement in Information subtest. However, the poor performances in Arithmetics and Coding subtests both pre and post-treatment reveal the persistence of J. K.'s attention problems. In the Arithmetics subtest, he answered the easier questions impulsively, not having the patience to really concentrate in counting, which led to wrong answers in easy tasks, while the more difficult questions he got right most of the time. In the Coding subtest, the main problem for J. K. could have been his visuomotor slowness, not necessary only his attention problems.

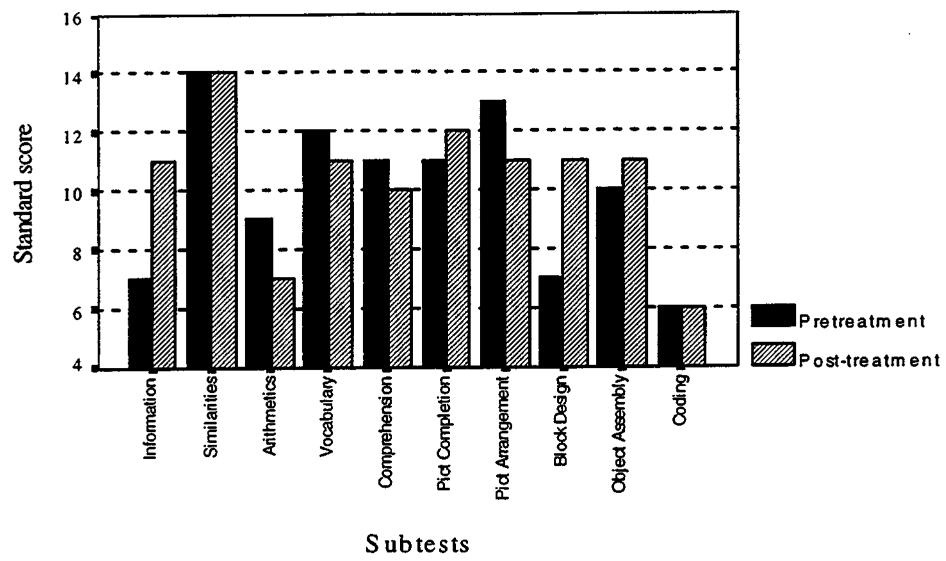


FIGURE 12. Standard scores of WISC-R subtests pre and post-treatment.

## Observational data: questionnaires

**Self-control rating scale**. Humphrey's (1982) self-control rating scale was filled out by J. K.'s parents five times in total: first time before training, second time after 10 sessions, third time after 20 sessions, fourth time after 30 sessions and fifth time after all 40 sessions were completed. In the questionnaire, there are 15 statements that describe cognitive and personal components of self-control such as planning (e.g. "plans ahead what to do before acting") and self-observation ("pays attention to what he or she is doing"). The statements were answered by circling a number from 1 (never) to 5 (very often) (questionnaire form in Appendix 1).

As can be seen in Figure 13, J. K.'s cognitive/personal self-control increased as did his behavioral/interpersonal self-control ratings by parents. There was a slight deterioration in his self-control ratings halfway through the training (after 20 sessions) which was probably due to his school year ending and the loss of his daily school routine. His behavioral self-control seemed to improve more than his cognitive/personal self-control even though neurofeedback concentrates in rehearsing cognitive self-control. Generalizing from the training situation into daily interpersonal situations seemed to have occurred.

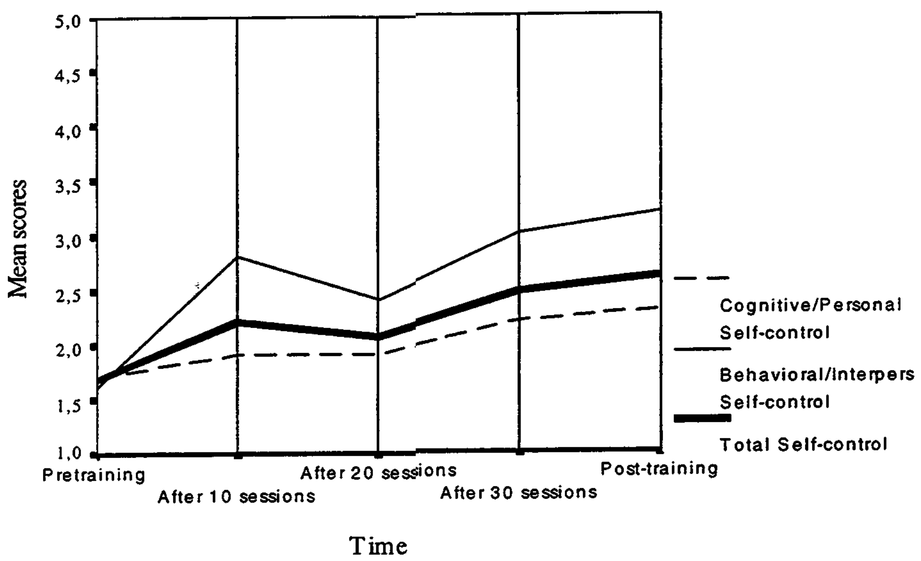


FIGURE 12. The development of the subject's self-control measured by Humphrey's (1982) self-control rating scale questionnaire which was filled out by the subject's parents. Higher score indicates better self-control.

**Teachers' rating scale for attention problems.** Jokinen's (1996) DSM-IV based questionnaire for teachers for rating attention problems was filled out by J. K.'s teacher four times in total: first time before training, second time after 4 weeks from the beginning of the training, third time after 12 weeks and fourth time after the training had been completed. The 37-item questionnaire tapped into six different areas of attention:

sustained attention, selectivity, flexibility, distractability, sensitivity to reinforcement and impulsiveness and hyperactivity. The statements were answered using a five point scale whose extremes were: "describes very well the child's behavior" and "describes very poorly the child's behavior". The higher the child's score is, the better is his/her behavior rated by the teacher (questionnaire form in Appendix 2).

J. K.'s behavior at school seemed to deteriorate during the training period rated by his teacher (Figure 14). Distractability was the only area of attention that stayed approximately the same. As J. K.'s training was mainly carried out during the summer vacation months, some amount of the deterioration could have been caused by his losing the school routine for two and a half months. He faced problems in trying to accommodate his behavior to the demands of school work again in the fall term 1997 and seemed to have had a couple of confrontations with his teacher. It can be concluded that according to his teacher's evaluation, his better cognitive/personal self-control skills failed to generalize into school setting.

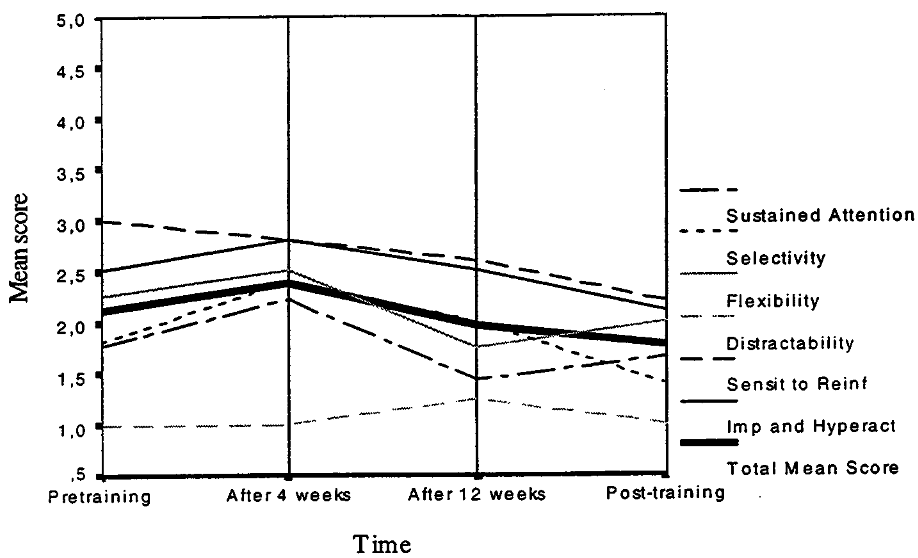


FIGURE 13. Teacher's evaluation of the subject's attention during training, measured by Jokinen's (1996) rating scale for attention problems questionnaire. Higher score indicates better attention.

# DISCUSSION

EEG biofeedback is a complicated method to apply to complex conditions like ADD. The procedure itself is not complicated, but if one wants to understand how it really works and what the exact theoretical basis for neurofeedback is, obviously a lot more research on it is needed. The literature reviewed paints a somewhat messy picture; many articles are outcome studies describing successful treatment experiments but there is a lack of consistency in method and application. Also, the development of theoretical foundations seems to be lacking in most studies.

In the present paper, the theoretical basis for neurofeeedback was the underarousal hypothesis which sees ADD symptoms resulting from an abnormally low autonomic and cortical arousal. According to the model, activation of the subject's arousal system, in the present study with neurofeedback training, would lead to higher and thus more normal levels of arousal, which would result in better concentration and less hyperactivity. In addition to this theoretical basis, the present study attempted to widen the scope of most of the neurofeedback studies and examined EEG readings in different situations: in passive baseline conditions, in active video game -like conditions and in feedback situations.

The subject's behavior change can be looked at from three different levels of behavior: first, the psychological learning to associate feedback rewards and scores and to learn to increase them; second, this learning reflected in psychophysiological measures; and third, this learning generalized to everyday life behavior in a multitude of settings. In the present study, J. K. succeeded in changing his behavior at the first and the second level; to increase his reward scores and thus to control his EEG pattern. However, he did not seem to be able to successfully transfer learned attentional skills to classroom environment according to his teacher at school. So even if a desired change in an ADD patient's EEG pattern is achieved, it is a whole different matter if it will reduce the patient's problematic behaviors and thus relieve his/her ADD symptoms outside the training situation.

A fixed model of neurofeedback therapy consisting of both SMR/theta and beta/theta paradigms linked to EMG reduction training was used in the present study. According to Lubar's model (personal communication, December, 1996), this two-phase model is best suited for ADD/+H patients. After the setting of thresholds, they stayed stable throughout the whole training. If rapid learning had occurred, they could have been changed accordingly (J. F. Lubar, personal communication, February, 1997). It seemed that the changing of thresholds according to the attention level more often, i.e. shaping, could have been more successful, because with the stationary thresholds the subject seemed to lose his motivation fairly easily.

J. K. learned to decrease his theta waves during the second block of 20 sessions of the training. During theta conditioning, it is interesting to notice that when comparing the average theta levels of baseline conditions, ATTE conditions and feedback conditions throughout the training, both the baseline graph and the ATTE graph go below the feedback graph in the successful second block of 20 sessions, indicating more attention and processing occurring during those conditions (Figures 7 and 8). This finding is the opposite to what was expected based on the neurofeedback paradigm's rationale that feedback produces enhanced concentration. It seems that in the present study the feedback conditions used as treatment elicited less activation than either staring at the blank screen or playing ATTE game. And as mentioned before, the desired theta reduction did not occur during the first block of SMR/theta training but solely during the second block of beta/theta training.

Quite a different picture was seen in the development of SMR and beta waves. The aim was to enhance SMR waves in the first block of training and it was modestly successful (see Figures 2 and 4). What was interesting and in line with the situational variation of concentration hypothesis, was that the different conditions produced different developments in the SMR graph. SMR was enhanced in only ATTE and feedback conditions, while in baseline conditions it decreased. The same occurred with beta waves in the second block of training: beta was clearly enhanced in ATTE and feedback conditions but reduced in baseline conditions. Thus ATTE game and EEG feedback promoted active cortical processing but during the breaks (baseline conditions), SMR and beta levels went down. Thus fluctuations in concentration between conditions became more evident, and J. K. learned to better adjust his attention to situational demands.

ATTE computerized attention assessment program was a good motivator for the subject with its video game -like appearance and the scoreboard kept during the training. When one looks at the EEG data collected during ATTE game conditions, it is evident that the game was also training the subject's concentration, not only assessing it. Indeed, theta wave reduction was best realized during ATTE conditions, making the game more successful in it than the EEG feedback conditions. The situation was the same with SMR enhancement, ATTE being more efficient than feedback conditions in eliciting SMR waves. However, feedback was more successful than ATTE game in eliciting beta.

When comparing the ATTE time series graphs and EEG graphs, they seem to go well together. Impulsiveness went down and the ability to concentrate (amount of liquid variable) went up, especially during the latter half of the training. The subject's self-control graph (efficiency variable) was a little more fluctuating but the trend seemed to be going upwards. There was a downward loop in the efficiency graph towards the end of the training which could have been due to difficulties in self-control when returning to school after summer vacation.

EMG reduction paradigm did not work well in the present study. J. K. did not learn to relax and sit still during the training, he seemed to have to move some while concentrating in the tasks. The fact that EMG training did not produce the desired effect might have occurred due to the view that effort in cognitive processing produces increased EMG activity.

WISC-R assessments yielded an increase in the performance scale IQ from 95 to 101, which can be considered as an enhancement in the subject's ability to concentrate and process information in the test situation. J. K.'s attention problems still affected his performance in the tasks, for example in the Arithmetics subtest. The verbal scale IQ stayed the same. It was evident that J. K.'s motivation and attitude were crucial in succeeding in the tasks given.

The parents' and teacher's questionnaires were useful in adding information about J. K.'s everyday behavior outside the clinic to the picture. The neurofeedback training started a month before summer vacation from school and ended a month after school had started in the fall again, and this affected greatly J. K.'s behavior on the basis of the evaluation questionnaires. When the vacation started, his self-control deteriorated as did the gains in attention made at school. This probably resulted from the loss of a stable daily routine which is of great importance to ADD children. The parents saw J. K.'s behavior and self-control progress later in the summer and in the fall along with the training, while according to his teacher, he seemed to have grave difficulties in adjusting to the demands of school again that fall.

J.K.'s mood and motivation varied greatly during his neurofeedback training period. He was very excited at the beginning of the training after getting used to the EEG equipment, but later on he often got frustrated with the results and had difficulties in sustaining his attention and effort. The scoreboards kept were of great importance to him. He needed continuous encouragement and sometimes strict verbal reminders in order to succeed. However, he seemed to enjoy it greatly when he did well in the games and he also developed an interest in reading for the first time.

The present pilot case study does indicate some support for the efficacy of neurofeedback training paradigm but also raises many questions. There clearly is potential in this method in that it can change EEG patterns, but the main problem is the generalization of the learned EEG control to everyday life situations. Transfer from the training situation to home and school settings is difficult because the real life context of the child is usually very different from the training situation. Thus active support from the family and the school of the child is extremely important in the process: neurofeedback training alone is not likely to alleviate ADD.

The finding that theta waves clearly decreased also during baseline conditions gives hope that the transfer from the training situation to real life in fact is possible. In order to enhance transfer, the training could be made less score driven, meaning that the child should learn to control his EEG with the help of more real life type rewarding factors than simple score rewards. Also, the feedback games themselves could be developed further because the ones used in the present study were not enough to capture the child's interest in the long run. Besides the feedback games themselves, explaining the child how the training works and how it should help him/her to concentrate better at home and at school increases the child's metacognition and thus possibly enhances self-control.

It would be important to measure EEG feedback rewards during different conditions and to train ADD patients to control their concentration according to situational demands, not only simply to decrease theta and increase SMR and beta. Also, the motivational factors need to be taken into consideration and linked to any ADD training program.

In conclusion, the child's arousal level reflected in EEG readings was increased and thus normalized via the neurofeedback method. The change was seen in the measured variables of ATTE attention assessment program linked to training, and somewhat in WISC-R scores and questionnaire scores.

Pragmatically, the most important finding is that the neurofeedback method seems to work for a lot of ADD patients and alleviates the symptoms without medication, but its wider acceptance as a viable alternative seems to require more rigorous and methodologically sound research.

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APPENDIX 1



# TOIMINTA-ARVIOINTI

Lapsen nimi ______________________ Pvm ______________

Ikä _____ Luokka ______________ Arvioijan nimi ____________

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1. On altis häiriöille tehdessään tehtäviä | Ei koskaan | 1 | 2 | 3 | 4 | 5 | Hyvin usein |
| 2. Kiinnittää huomionsa siihen mitä tekee | Hyvin usein | 1 | 2 | 3 | 4 | 5 | Ei koskaan |
| 3. Hänen täytyy heti saada haluamansa asiat | Ei koskaan | 1 | 2 | 3 | 4 | 5 | Hyvin usein |
| 4. Ennakoi toimintojensa seuraukset | Hyvin usein | 1 | 2 | 3 | 4 | 5 | Ei koskaan |
| 5. Hän tietää, milloin käyttäytyy huonosti, vaikka sitä ei hänelle sanotakaan | Hyvin usein | 1 | 2 | 3 | 4 | 5 | Ei koskaan |
| 6. Turhautuu ja/tai luovuttaa vaikeissa tehtävissä | Ei koskaan | 1 | 2 | 3 | 4 | 5 | Hyvin usein |
| 7. Puhuu odottamatta vuoroaan | Ei koskaan | 1 | 2 | 3 | 4 | 5 | Hyvin usein |
| 8. Hänellä on vaikeuksia pitää lupauksiaan. | Ei koskaan | 1 | 2 | 3 | 4 | 5 | Hyvin usein |
| 9. Epäonnistuu tehtävien suorittamisessa, jos aikuinen ei valvo niiden tekemistä | Ei koskaan | 1 | 2 | 3 | 4 | 5 | Hyvin usein |
| 10. Suunnittelee etukäteen, mitä tulee tehdä ennen kuin toimii | Hyvin usein | 1 | 2 | 3 | 4 | 5 | Ei koskaan |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 11. Tekee sitkeästi loppuun saakka jopa pitkiä ja epämiellyttäviä tehtäviä | Hyvin usein | 1 | 2 | 3 | 4 | 5 | Ei koskaan |
| 12. Häiritsee muita, kun he tekevät tehtäviään | Ei koskaan | 1 | 2 | 3 | 4 | 5 | Hyvin usein |
| 13. Joutuu riitoihin tai tappeluihin muiden lasten kanssa | Ei koskaan | 1 | 2 | 3 | 4 | 5 | Hyvin usein |
| 14. Tekee huolimattomuusvirheitä, koska hätiköi tehtävien teossa | Ei koskaan | 1 | 2 | 3 | 4 | 5 | Hyvin usein |
| 15. Työskentelee päämäärätietoisesti | Hyvin usein | 1 | 2 | 3 | 4 | 5 | Ei koskaan |

APPENDIX 2



# OPPILAAN TARKKAAVAISUUDEN ARVIOINTILOMAKE

Arvioija:______________________________

Oppilas:______________________________

**Mieti oppilaan käyttäytymistä viimeisen puolen vuoden aikana ja arvioi, kuinka hyvin seuraavat väittämät kuvaavat oppilasta. Rastita kuvaavin vaihtoehto.**

| | Kuvaa erittäin hyvin | | | | Kuvaa erittäin huonosti |
|---|---|---|---|---|---|
| 1. Jaksaa tehdä työnsä tarkasti ja huolellisesti. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 2. On usein vaikeuksia ylläpitää tarkkaavaisuutta tehtävissä tai leikeissä. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 3. Ei useinkaan näytä kuuntelevan kun hänelle puhutaan. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 4. On usein vaikeuksia toimia annettujen ohjeiden mukaisesti ja suorittaa tehtävät loppuun. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 5. Välttää usein tai on haluton suorittamaan tehtäviä, jotka vaativat pitkäjännitteistä henkistä ponnistelua. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 6. Kadottaa usein tavaroita, jotka olisivat tarpeen tehtävien suorittamisessa (esim. kyniä, kirjoja tai muita koulutarvikkeita). | ☐ | ☐ | ☐ | ☐ | ☐ |
| 7. On usein vaikeuksia kiinnittää huomiota yksityiskohtiin tai oppilas tekee huolimattomuusvirheitä koulutyössä. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 8. Oppilaalla on usein vaikeuksia organisoida toimintaansa. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 9. Oppilaalle sattuu usein unohtamisia jokapäiväisissä toimissaan. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 10. Tarkkaavaisuus suuntautuu tunnilla muuhun kuin opetettavaan asiaan. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 11. Pystyy suorittamaan kahta tehtävää samanaikaisesti (esim. kykenee solmimaan kengännauhat kun samalla tulee ottaa vastaan ohje ja ymmärtää se). | ☐ | ☐ | ☐ | ☐ | ☐ |
| 12. Pystyy keskittymään omaan tehtäväänsä kun opettaja opettaa muita. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 13. Ohjeet on annettava oppilaalle lyhyesti ja vaiheittain edeten. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 14. Jaksaa seurata opetettavaa asiaa, eikä häiriinny epäolennaisesta. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 15. Vaihtaa sujuvasti työtapaa (esim. siirtyminen peruslaskutavasta toiseen saman opetusjakson aikana). | ☐ | ☐ | ☐ | ☐ | ☐ |
| 16. Rutiinien muuttuminen aiheuttaa oppilaassa levottomuutta, oppilas vastustaa muutosta (esim. lukujärjestyksestä poikkeamista). | ☐ | ☐ | ☐ | ☐ | ☐ |
| 17. Opettajan seuraamisen ja oman työn vuorottelu on vaikeaa (esim. oppilaan on vaikeata jäljentää tehtäviä taululta vihkoonsa). | ☐ | ☐ | ☐ | ☐ | ☐ |
| 18. Takertuu ensin käyttämäänsä työtapaan (pyrkii tekemään kaikki tehtävät saman "kaavan" mukaan). | ☐ | ☐ | ☐ | ☐ | ☐ |

KÄÄNNÄ !

| | Kuvaa erittäin hyvin | | | | Kuvaa erittäin huonosti |
|---|---|---|---|---|---|
| 19. Häiriintyy helposti ulkopuolisista ärsykkeistä. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 20. Pystyy keskittymään omaan tehtäväänsä vaikka jokaisella oppilaalla on omat, eriytetyt tehtävänsä. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 21. On vaikeuksia työskennellä paikassa, josta voi seurata luokkatovereita tai muuta mielenkiintoista (esim. luokan takaosassa tai ikkunan vieressä). | ☐ | ☐ | ☐ | ☐ | ☐ |
| 22. Pystyy paneutumaan tehtäväänsä, vaikka ympärillä on hälinää. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 23. Lannistuu välittömästi vastoinkäymisestä. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 24. Jaksaa pysyä asiassa vain saadessaan riittävästi huomiota (vaatii opettajalta usein palautetta). | ☐ | ☐ | ☐ | ☐ | ☐ |
| 25. Pettymysten ja epäonnistumisten sietäminen on oppilaalle vaikeaa. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 26. Oppilaalle on samantekevää miten hän suoriutuu tehtävistä ("hällä-väliä" -mentaliteetti). | ☐ | ☐ | ☐ | ☐ | ☐ |
| 27. Jaksaa yrittää vaikka epäonnistuisi tehtävän suorittamisessa. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 28. Oppilaan on usein vaikeaa odottaa vuoroaan. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 29. Juoksentelee ja kiipeilee usein sopimattomissa tilanteissa. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 30. Vastaa usein ennen kuin kysymystä on ehditty kokonaan esittää. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 31. Keskeyttää tai häiritsee usein muita (esim. keskeyttää keskustelun tai leikin). | ☐ | ☐ | ☐ | ☐ | ☐ |
| 32. Vaikeuksia toimia rauhallisesti leikki- tai pelitilanteissa. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 33. Liikuttelee usein hermostuneesti käsiään tai jalkojaan tai vääntelehtii istuimellaan. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 34. Poistuu usein paikaltaan luokassa tai muussa tilanteessa, jossa edellytettäisiin paikallaan istumista. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 35. Puhuu usein liikaa. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 36. Jaksaa odottaa omaa vuoroaan esim. viittaamalla. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 37. On jatkuvasti liikkeessä. | ☐ | ☐ | ☐ | ☐ | ☐ |

Mikä on mielestäsi silmiinpistävintä oppilaan käyttäytymisessä? ____________________

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Miten otaksut oppilaan menestyvän tietokonepelissä? ____________________

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