ผลของการให้ข้อมูลป้อนกลับทางชีวภาพแบบคลื่นสมองและการเสริมแรงทางบวกต่อพฤติกรรมตั้งใจทำกิจกรรมคณิตศาสตร์ของเด็กสมาธิสั้นและมีพฤติกรรมไม่อยู่นิ่ง

นางสาวสุภลัคน์ ลวดลาย

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาศิลปศาสตรมหาบัณฑิต
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EFFECTS OF EEG-BIOFEEDBACK AND POSITIVE REINFORCEMENT ON ATTENTIONAL BEHAVIOR TO MATHEMATICS ACTIVITIES OF ATTENTION- DEFICIT/HYPERACTIVITY DISORDER CHILDREN

Miss Supalak Luadlai

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for the Degree of Master of Arts in Developmental Psychology
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Thesis Title	Effects of EEG-Biofeedback and Positive Reinforcement on Attentional Behavior to Mathematics Activities of Attention-Deficit/Hyperactivity Disorder Children
By	Miss Supalak Luadlai
Field of Study	Developmental Psychology
Thesis Advisor	Associate Professor Sompoch Iamsupasit, Ph.D.

Accepted by the Faculty of Psychology, Chulalongkorn University in Partial Fulfillment of the Requirement for the Master's Degree

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สุภลัคน์ ลวดลาย ชื่อวิทยานิพนธ์: ผลของการให้ข้อมูลป้อนกลับทางชีวภาพแบบคลื่นสมองและการเสริมแรงทางบวกต่อพฤติกรรมตั้งใจทำกิจกรรมคณิตศาสตร์ของเด็กสมาธิสั้นและมีพฤติกรรมไม่อยู่นิ่ง (EFFECTS OF EEG-BIOFEEDBACK AND POSITIVE REINFORCEMENT ON ATTENTIONAL BEHAVIOR TO MATHEMATICS ACTIVITIES OF ATTENTION-DEFICIT/HYPERACTIVITY DISORDER CHILDREN)

อ.ที่ปรึกษา: รองศาสตราจารย์ ดร.สมโภชน์ เอี่ยมสุภาษิต: 129 หน้า. ISBN 974-17-2796-8

การวิจัยครั้งนี้มีวัตถุประสงค์เพื่อศึกษาผลของการให้ข้อมูลป้อนกลับทางชีวภาพแบบคลื่นสมองและการเสริมแรงทางบวกต่อการเพิ่มพฤติกรรมตั้งใจทำกิจกรรมคณิตศาสตร์ของเด็กอายุระหว่าง 9.5 -10.5 ปี ที่มีอาการสมาธิสั้นและมีพฤติกรรมไม่อยู่นิ่ง กลุ่มตัวอย่างประกอบด้วยเด็กสมาธิสั้นและมีพฤติกรรมไม่อยู่นิ่ง จำนวน 6 คน เป็นเด็กหญิง 1 คนและเด็กชาย 5 คน โดยกลุ่มตัวอย่างทั้งหมดได้รับการวินิจฉัยจากแพทย์แล้วว่ามีอาการสมาธิสั้นและมีพฤติกรรมไม่อยู่นิ่ง แบบเน้นอาการขาดสมาธิ และเพื่อเป็นการยืนยันการวินิจฉัยของแพทย์ ผู้วิจัยได้ขออนุญาตให้ผู้ปกครองและครูผู้สอนของกลุ่มตัวอย่างตอบแบบสอบถาม ADHD-Symptom Inventory และ(ADHD-SI) ADHD/DSM-IV Scales (CADS) ซึ่งผลปรากฏว่ากลุ่มตัวอย่างทั้งหมดเป็นเด็กสมาธิสั้นและมีพฤติกรรมไม่อยู่นิ่ง แบบเน้นอาการขาดสมาธิจริง หลังจากนั้นผู้วิจัยได้แบ่งเด็กออกเป็น 2 กลุ่มโดยการสุ่มตัวอย่าง คือ กลุ่มทดลองและกลุ่มควบคุม การทดลองจะใช้วิธีดำเนินการทดลองแบบ ABA Control Group Research Design การเก็บข้อมูลและการวิเคราะห์ผลการวิจัยจะแบ่งออกเป็น 2 มิติคือ พฤติกรรมตั้งใจทำกิจกรรมคณิตศาสตร์และอัตราส่วนการเพิ่มของคลื่นสมองแบบ Beta/Theta ผู้วิจัยวิเคราะห์ข้อมูลโดยการทดสอบทางสถิติแบบ t-test

ผลการวิจัยพบว่า (1) ในช่วง Baseline เด็กในกลุ่มทดลอง(M=7.26, SD=6.43) และกลุ่มควบคุม (M=9.19, SD=10.96) มีพฤติกรรมตั้งใจทำกิจกรรมคณิตศาสตร์ไม่แตกต่างกัน (2) ในช่วง Treatment พบว่าเด็กในกลุ่มทดลองมีพฤติกรรมตั้งใจทำกิจกรรมคณิตศาสตร์สูงกว่าเด็กในกลุ่มควบคุมอย่างมีนัยสำคัญทางสถิติที่ระดับ .05 [t(38)=44.009, p<.05] ในส่วนของอัตราส่วนการเพิ่มขึ้นของคลื่นสมอง Beta /Theta พบว่า (1) ไม่มีความแตกต่างของการอัตราส่วนการเพิ่มขึ้นของคลื่นสมอง Beta/Theta ของกลุ่มทดลอง (M=0.99, SD=0.54) และกลุ่มควบคุม (M=0.64, SD=0.11) ในช่วง Baseline (2) ในช่วง Treatment พบว่าอัตราส่วนการเพิ่มขึ้นของคลื่นสมอง Beta/Theta ทั้งในกลุ่มทดลอง (M=0.68, SD=0.10) และกลุ่มควบคุม (M=0.63, SD=0.15) ไม่มีความแตกต่างกัน

สาขาวิชา…จิตวิทยาพัฒนาการ………….. ลายมือชื่อนิสิต…………………………………………………………

ปีการศึกษา………2545………………….. ลายมือชื่ออาจารย์ที่ปรึกษา…………………………………………

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KEY WORD: ATTENTION-DEFICIT/HYPERACTIVITY DISORDER /EEG-BIOFEEDBACK /EEG BRAINWAVES/ ATTENTIONAL BEHAVIOR

SUPALAK LUADLAI : EFFECTS OF EEG-BIOFEEDBACK AND POSITIVE REINFORCEMENT ON ATTENTIONAL BEHAVIOR TO MATHEMATICS ACTIVITIES OF ATTENTION-DEFICIT/HYPERACTIVITY DISORDER CHILDREN.

THESIS ADVISOR: ASSOCIATE PROFESSOR SOMPOCH IAMSUPASIT, Ph.D.:, 129 pp., ISBN 974-17-2796-8

This study examined the hypothesis that EEG biofeedback and positive reinforcement could improve attentional behavior of 9.5 to 10.5 year-old children with ADHD. Six children (one girl and five boys) participated in this study. The researcher randomly assigned the participants into experimental and control groups with 3 children in each group. All participants were diagnosed with ADHD (in inattentive type) by the physician. Additional assessment, using ADHD-Symptom Inventory and, parent and teacher versions of ADHD/DSM-IV Scales confirmed physicians for all the participants. An ABA Control Group research design was applied. The data was collected into two dimensions, attentional behaviors and beta/theta brainwaves. Child attentional behaviors in both experimental and control groups were compared across baseline and treatment phases by using t-test. Ratio of beta and theta brainwaves of both groups was calculated and then compare with those ratios across baseline and treatment phases by using t-test.

The results of attentional behaviors showed that (1) there was no difference in attentional behavior for experimental (M = 7.26, SD = 6.43) and control groups (M= 9.19, SD= 10.96) during baseline phase. (2) The participants in experimental group performed significantly more attentional behavior than control group during the treatment phase [t(38)= 44.009, p< .05]. The results of beta/theta brainwaves ratios showed that (1) there was no difference in the beta/theta brainwaves ratio between experimental (M= 0.99, SD= 0.54) and control groups (M= 0.64, SD= 0.11) during the baseline phase and (2) there was also no difference in beta/theta brainwaves ratio between experimental (M=0.68, SD= 0.10) and control groups (M= 0.63, SD = 0.15) during the treatment phase.

Field of Study …Developmental Psychology……….. Student's Signature……………………………...

Academic Year …….2002……… Advisor's Signature………………………………

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Supalak Luadlai

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Introduction

Background of the Study

Attention-deficit/hyperactivity disorder (ADHD) is one of the most commonly diagnosed, impairing, widely researched, and controversial of child clinical syndromes (Barkley, 1997). A review of epidemiological studies suggest that the prevalence of the disorder is approximately 5% and that it occurs in boys approximately three times as often as in girls (Barkley, 1998). In Thailand, the data from the Office of the National Primary Education Commission (1994 cited in Srichai, 2000) showed that there were 153,000 t0 408,000 children with ADHD in public elementary schools in 1994. The officers believed that the number of children with ADHD in Thailand may be larger than in this survey because the data did not cover those children in private school.

Children with ADHD display difficulties with attention relative to normal children of the same age and gender. However, attention is a multidimensional construct that can refer to alertness, arousal, selectivity, sustained attention, distractibility, or span of apprehension (Barkley, 1988; Hale & Lewis, 1979; Mirsky, 1996 cited in Barkley, 1998). Research suggests that ADHD children have their greatest difficulties with persistence of effort, or sustaining their attention (responding) to tasks (Douglas, 1983). Parents and teachers often describe these attentional problems in terms such as “Doesn’t seem to listen,” “Fails to finish assigned tasks,” “Daydream,” “ Often loses things,” Can’t work independently of supervision,” “Requires more redirection,” “Shifts from one uncompleted activity to another,” and “Confused or seems to be in a fog” (Barkley, DuPaul, & McMurray, 1990; Stewart, Pitts, Craig, & Dieruf, 1966). Many of these terms are the most frequently endorsed items from rating scales completed by the caregivers of these ADHD children. Studies using direct observations of child behavior find that off-task behavior (i.e., not paying attention to work) is recorded substantially more often for ADHD children and adolescents than for learning-disabled or normal children

(Abikoff, Gittelman-Klein, Klein, 1977; Barkley et al., 1990; Luk, 1985; Fischer, Barkley, Edelbrock, & Smallish, 1990, Ullman, Barkley, & Brown, 1978).

ADHD is also frequently associated with what is called “impulsivity” or, a deficiency in inhibiting behavior in response to situational demands compared to others of the same mental age and gender. Like attention, impulsivity is also multidimensional in nature (Kindlon, Mezzacappa, & Earls, 1995). The third primary characteristic of those with ADHD is their excessive or developmentally inappropriate levels of activity, whether motor or vocal. Restlessness, fidgeting, and generally unnecessary gross bodily movements are commonplace (Barkley, Cunningham, & Kalsson, 1983; Luk, 1985). In adults with ADHD, symptoms of hyperactive or restless behavior are often presented but appear to involve more difficulties with fidgeting, subjectively experienced restlessness, and excessive speech than the motor overactivity of young ADHD children (Barkley, 1998).

Besides their primary problems with inattention, impulsivity, and overactivity, Children with ADHD may have a variety of other difficulties. Such children have a higher likelihood of having other cognitive, developmental, behavioral, emotional, academic, and even medical difficulties. Not all ADHD children display all these problems, but many display them to a degree that is greater than expected in normal children (Barkley, 1998). Children with ADHD are more likely to be behind in their intellectual development than either normal children or the siblings of the ADHD children manifesting an average of 7 to 15 points below the normal children and their siblings on standardized intelligence tests (Faraone et al., 1993; Fischer, Barkley, Fletcher, & Smallish, 1990; McGee, Williams, Moffitt, & Anderson, 1989; Werry, Elkind, & Reeves, 1987). It is not clear whether these differences in scores represent real differences in intelligence or ADHD children have more inattentive and impulsive test-taking behavior. It is also possible that because these studies often used mixed groups of children having both ADHD and Learning Disability (LD), the lower intelligence scores in the ADHD groups could be related to the coexisting learning disorder and not to the ADHD per se, as some have suggested (Bohline, 1985). However, in a clinic study of ADHD and LD children, LD children who did not also have ADHD actually had IQ estimates lower than those found in the mixed ADHD/LD group whose IQ estimates were still lower than the normal control group (Barkley et al., 1990). Differences in IQ have also been found in hyperactive boys and their normal siblings (Hinshaw, 1992). ADHD is associated with greater risks for delayed motor coordination (up to 52%), poor self-regulation of emotion, poor school performance, low academic achievement, retention in grade, school suspension and expulsion, and driving accidents and speeding violations (Barkley, 1998). The disorder persists into adolescence in 50-80% of cases clinically diagnosed in childhood and into adulthood in 30-50% or more of these same cases (Barkley et al., 1990; Klein & Mannuzza, 1991; Weiss & Hectman, 1993 cited in Barkley, 1997). Certainly, ADHD can be debilitating in terms of achieving educational objectives, maintaining employment, and developing careers. It is a disorder that can be extremely disruptive within family systems and affects most aspects of one's ability to function effectively in a complex society and to set and achieve important life goals (Lubar, 1995).

Attention-deficit/hyperactivity disorder (ADHD) exists in all countries and in all cultures (Lubar, 1995). Because ADHD symptoms are so severe, so, there are many treatments for ADHD. The existing treatments are the following;

1. Pharmachotherapy

From the stand point of many who are in charge of managing children's behaviors, medication is the treatment of choice for children with ADHD . Virtually every type of medication available has been prescribed for these children at one time or another. The most effective medication for treating children with ADHD is "Methylphenidate" or "Ritalin". Methylphenidate is frequently given in divided doses, at breakfast and at lunch. The breakfast dose is often double the lunch dose, to avoid insomnia. If possible, a third dose is avoided to decrease side effects, although for some children a third dose is helpful and does not increase side effects (Weiss, 1998). Across different studies, up to 70% of children with ADHD who were treated with methylphenidate have been reported to exhibit a significant clinical response (Greenhill, 1992). It effects on the cognitive processes which improve the ability to perform difference tasks (Kramer, Cepeda, & Cepeda, 2001). Methylphenidate also increases on-task behavior, academic performance (Rapport, Murphy, & Bailey, 1982), and child classroom performance (Elia, Welsh, Gullotta, & Rapoport, 1993). Moreover, Losier, Magrath, and Klein (1996) found that children with ADHD who were treated with methylphenidate had significant reductions in omission and commission errors. However, recent studies found that there was not statistically significant response difference between methylphenidate and placebo in children with ADHD (Rosen, O'Leary, & Conway, 1985; Murray & Kollins, 2000) and adult with ADHD (Kuperman et al., 2001). Further, methylphenidate also has the side effects. The most common side effects are reduced appetite and difficulty getting to sleep. Some children report stomachache or headache. Occasionally they have some reactions such as seemed unhappiness, nightmares, anxiousness, biting fingernails, nervous movements in children have been reported (Elia et al., 1993, Daryl & Frederick, 1997). Recently there was a report of delusion. However, these side effects depend on the dosage of medication and no cases of psychotic reaction persisting after medication was discontinued have been reported (Weiss,1998). Other medications found useful in treating ADHD are Dextroamphetamine sulfate (Dexedrine), Pemolin (Cylert), Thioridazine (Mellaril) and Pindolol. These drugs have been proven effective in increasing attention and decreasing impulsive behavior (Horn, Chartor, & Conner, 1983 cited in Frazier & Merrell, 1997), or hyperactive responding and conduct problem (Buitelaar, Jan van der Gaag, Swaab-Barneveld, & Kuiper, 1996). They have also been found to improve cognitive functioning (Corners & Taylor, 1980), but like methylphenidate, they have side effects such as anorexia, insomnia, weight lost, and stomach pains (Golinko, 1982). Therefore, careful attention to dosage levels should be made when these medications are administered (Buitelaar et al., 1996).

2. Nonphamacological Treatment. Concern about the possible overuse of stimulants and disappointment over their lack of sufficient effect led to a search for nonpharmacological treatment for ADHD, or nonpharmacological treatment in combination with stimulants. The treatments include:

2.1 Behavior Therapy Behavioral treatment is utilized to change unwanted behaviors through the manipulation of environmental antecedents and consequences. Behavioral antecedents (setting events for behavior) are identified and then modified or replaced by new, more adaptive ones. Environmental consequences (results of behavior such as reinforcers and punishers) are also manipulated to control behavior (Watson & Tharp, 1989 cited in Frazier & Merrell, 1997). The basic behavioral treatment approaches used in ADHD include positive reinforcement procedures (e.g., use of praise, attention, and rewards), punishment procedures (e.g., time-out, over correction, and response cost), and combinations of both (e.g., token economies and contingency contracting) (Frazier & Merrell, 1997). Behavioral intervention techniques have many advantages over other methods. Unlike medication, they have no physical side effects. They are very useful in the home setting and during even hours when medication can not be used. Used in conjunction with medication, behavioral interventions allow for lower dosages, thereby decreasing the severity of side effects. They also have effects complementary to psychostimulant medications, resulting in a broader coverage of symptoms. Finally, behavioral interventions can be used with children who do not respond well to medication or for whom the use. of medication is contraindicated by other problems. However, behavioral interventions also have limitations. For example, behavioral interventions are not effective for all children, and by themselves are rarely sufficient to bring a child to the normal range of functioning (Pelham, Jr., 1991). Since ADHD is a chronic disorder, behavioral interventions must be lengthy, intensive, and used throughout the child’s environment (Chronis, Fabiano, Gnagy, Wymbs, Burrows-MacLean, & Pelham, Jr., 2001). They usually require a great deal of time and energy. It can be quite difficult, therefore, to get parents and teachers to consistently implement behavioral methods over a long period of time. Finally, there is a lack of evidence supporting the long-term effects and generalizability of behavioral interventions (Pelham, Jr., 1991).

2.2 Cognitive-Behavioral Therapy (CBT) Cognitive-behavioral training was designed to teach hyperactive children self-control, self-guidance, and reflective, more efficient problem-solving strategies (Weiss, 1998). Mostly, two techniques have been used: reinforced self-evaluation and anger management (Frazier & Merrell, 1997). Hinshaw and Melnick (1992) found that reinforced self-evaluation and anger management was used to successfully improve the behavior of children with ADHD (Hinshaw & Melnick, 1992). Hinshaw, Henker, and Whalen (1984) also examined the effects of reinforced self-evaluation on ADHD boys. They found greater amounts of appropriate social behavior and decreased frequencies of negative social behavior for those boys who were taught reinforced self-evaluation compared to pharmacological and behavioral strategies. Moreover, some researchers used the self-control technique to teach children with ADHD. They found that using "self-control" in a choice paradigms to children with ADHD, they could control themselves to wait for the larger reward and choose more delayed rewards over smaller or more immediate one (Ainsile, 1974; Fantino, 1966; Mazur & Logue, 1978; Rachlin & Green, 1972). Research with nonhuman animals (Ainsile, 1975; Chung & Herrnstein, 1967) and children (Schweitzer & Sulzar-Azaroff, 1988) has found that delay between choice and reward can affect preference, with choice for larger rewards diminishing as the delay increases. In children with ADHD, length of delay has been found to be more important to choice than the quantity of reward available (Rapport, Tucker, Dupaul, Merlo, & Stoner, 1986; Schwitzer & Sulzer-Azaroff, 1995). Further, when the researcher continued the self-control technique on hyperactive children for follow-up 1-year later, they found significant improvement of the children behavior (Kendall & Zupan, 1981; Kendall, 1982). However, a comprehensive review of this treatment (Abikoff, 1982 cited in Weiss, 1998) outlined the techniques utilized but was unable to confirm that it was helpful. Cognitive behavior therapy studies of the mechanisms and processes that cause lasting therapeutic changes are lacking (Ellis, 1997). The possible ceiling effect on medication and the failure to build in generalization into the classroom have been suggested as accounting for the negative results. Research on how cognitive training techniques can be modified to be more effective is continuing (Weiss, 1998).

2.3 Parent Training (PT) The most important goal of parent training (PT) is to provide parents with ongoing clinical supervision in the use of specialized contingency management techniques to address the noncompliance and other behavioral problems displayed by children with ADHD. A second objective is to facilitate parental adjustment to having a child with ADHD, primarily through the use of cognitive therapy strategies. In parent training, we may also use cognitive therapy strategies to help the parents achieve a third goal--increasing parental compliance with the prescribed treatment regimens. Finally, it is the overall purpose of this treatment program to provide parent with coping skills that will lead to happier and less stressful lives both for themselves and for their children (Barkley, 1998). The steps of parent training include assigning homework and keeping behavioral and reinforcement charts, and reporting on their efforts and experiences (Weiss, 1998). Wolfe et al. (Wolfe, Lawrence, Graves, Brehony, Bradlyn, & Kelly, 1982) found that using a direct parent training technique (bug-in-the-ear) could decrease hostile parent behavior and increase positive behaviors during stimulated problematic parent-child interactions in the clinic. The mother's hostile verbal and physical prompts were also reduced by prompting and feedback by the therapist. The mother's positive behavior also improved when training was introduced. Moreover, they found improvements in parent-child interaction in both the clinic and home settings and were maintained in these settings following the withdrawal of the training procedure and subsequent 2-month posttreatment follow-up. Although, systematized results were reported, parents found the procedure helpful in understanding their children's difficulties and dealing with their problems more effectively (Brestan, Jacobs, Rayfield, & Eyberg, 1999; Calvert & McMahon, 1987; Weiss, 1998).

2.4 EEG Biofeedback or Neurofeedback Operant conditioning of the EEG is called EEG biofeedback, neurofeedback or neurotherapy (Nash, 2000). It is an advanced form of biofeedback which allows the development of self-control over the person's brainwaves activity. The mechanism of how EEG biofeedback could help children with ADHD is based on the separation of certain brainwave patterns (Alhambra, Fowler, & Alhambra, 1995). Children with ADHD produce excess theta activity (4-8Hz known as slow wave activity and is associated with states such as daydreaming and drowsiness) and lower amounts of beta wave (15-35 Hz—high alertness) (Lubar, 1991). Children with ADHD were taught to increase beta waves and decrease theta waves during these tasks. Many recent studies of EEG biofeedback have shown that children with ADHD demonstrated considerable improvement in their school grades or achievement test scores (Lubar, & Lubar, 1984), and significant improvements in attention, impulse control, speed of information processing and consistency of attention as measured by the Test of Variables of Attention (TOVA) (Lubar, Swartwood, Swarwood, & O'Donnell, 1995; Rossiter & La Vaque, 1995; Ramirez, Desantis, & Opler, 2001). Moreover, children showed significant increases in WISC-R score and improved behavioral ratings after neurofeedback training (Lubar, Swartwood, Swarwood, & O'Donnell, 1995). The most important finding is that EEG biofeedback has been found to be an effective alternative to the use of psychostimulant medication for many children with ADHD. It is non-evasive and has few, if any, side effects. It is relatively easy for the trainer and child to do. However, EEG biofeedback treatments alone have not been effectively evaluated and have not been generalized because there are usually performed in clinical settings and are more expensive in the short-term than medication programs (Rossiter et al., 1995). Therefore, EEG biofeedback treatment should be combined with other techniques. EEG biofeedback appears to have promise for reducing some of the behavioral symptoms of ADHD (Lee, 1991).

It seems that many treatments are effectively successful on ADHD symptoms. Although no treatment has been found to cure ADHD, some treatments have been found to reduce the degree of impairment and severity of ADHD symptoms (Association for Advancement of Behavior Therapy, 1990).

As mention above, the symptoms of ADHD are severe and there are a large number of children with ADHD in Thailand. Therefore, this study attempts to find the appropriate treatment to reduce the symptoms. The treatment should be effective and not have adverse side effects for the participant. Therefore, the researcher in the present study chose a combined EEG-biofeedback technique with positive reinforcement and parent training to treat children with ADHD.

Review of Literature

Meaning, Diagnostic, and Types of Attention-Deficit/Hyperactivity Disorder

According to the Diagnostic and Statistical Manual of Mental Disorder (4th ed.)Text Revision (DSM-IV-TR^{TM}; American Psychiatric Association, 2000), the essential feature of Attention-Deficit/Hyperactivity Disorder is a persistent pattern of inattenttion and/or hyperactivity-impulsivity that is more severe than is typically observed in individuals at a comparable level of development (Criterion A). Some hyperactivity-impulsive or inattentive symptoms that cause impairment must have been present before age seven years, although many individuals are diagnosed after the symptoms have been present for a number of years, especially in the case of individuals with the Predominantly Inattentive Type (Criterion B). Some impairment from the symptoms must be present in at least two setting (e.g., at home and at school or work) (Criterion C). There must be clear evidence of interference with developmentally appropriate social, academic, or occupational functioning (Criterion D). The disturbance does not occur exclusively during the course of a Pervasive Developmental Disorder, Schizophrenia, or other Psychotic Disorder and is not better accounted for by another mental disorder (e.g., a Mood Disorder, Anxiety Disorder, Dissociative Disorder, or Personality Disorder) (Criterion E).

Diagnostic criteria for Attention-Deficit/Hyperactivity Disorder

A. Either (1) or (2)

(1) six (or more) of the following symptoms of inattention have persisted for at least six months to degree that is maladaptive and inconsistent with developmental level:

Inattention

(a) often fails to give close attention to details or makes careless mistakes in school work, work, or other activities.

(b) often have difficulty sustaining attention in tasks or play activities

(c) often does not seem to listen when spoken to directly

(d) often does not follow through on instructions and fails to finish schoolwork, chores, or duties in the workplace (not due to oppositional behavior or failure to understand instructions)

(e) often has difficulty organizing tasks and activities

(f) often avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort (such as schoolwork or homework)

(g) often loses things necessary for tasks or activities (e.g., toys, school assignments, pencils, books, or tools)

(h) is often easily distracted by extraneous stimuli

(i) is often forgetful in daily activities

(2) six (or more) of the following symptoms of hyperactivity-impulsivity have persisted for at least six months to a degree that is maladaptive and inconsistent with developmental level:

Hyperactivity

(a) often fidgets with hands or feet or squirms in seat

(b) often leaves seat in classroom or in other situations in which remaining seated is expected

(c) often runs about or climbs excessively in situations in which it is inappropriate (in adolescents or adults, may be limited to subjective feelings of restlessness)

(d) often has difficulty playing or engaging in leisure activities quietly

(e) is often “on the go” or often acts as if “driven by a motor”

(f) often talk excessively

Impulsivity

(g) often blurts out answers before questions have been completed

(h) often has difficulty awaiting turn

(i) often interrupts or intrudes on others (e.g., butts into conversations or games)

B. Some hyperactive-impulsive or inattentive symptoms that caused impairment were present before age 7 years.

C. Some impairment from the symptoms is present in two or more setting (e.g., at school (or work) and at home).

D. There must be clear evidence of clinically significant impairment in social, academic, or occupational functioning.

E. The symptoms do not occur exclusively during the course of a Pervasive Developmental Disorder, Schizophrenia, or other Psychotic Disorder and are not better accounted for by another mental disorder (e.g., Mood Disorder, Anxiety Disorder, Dissociative Disorder, or a Personality Disorder).

Code based on typed:

Attention-Deficit/Hyperactivity Disorder, Combined Type: if both Criteria A1 and A2 are met for the past six months

Attention-Deficit/Hyperactivity Disorder, Predominantly Inattentive Type: if Criterion A1 is met but Criterion A2 is not met for the past six months

Attention-Deficit/Hyperactivity Disorder, Predominantly Hyperactive-impulsive Type: if Criterion A2 is met but Criterion A1 is not met for the past six months

Coding note: For individuals (especially adolescents and adults) who currently have symptoms that no longer meet full criteria, “In Partial Remission” should be specified.

Etiologies

1. Neurological Factors

Brain damage resulting from known brain infections, trauma, or other injuries or complications occurring during pregnancy or at the time of delivery was initially proposed as a chief cause of ADHD symptoms (Barkley, 1998). Several studies have shown that brain damage, particularly hypoxic/anoxic types of insults, are associated with greater attention deficit and hyperactivity (Cruickshank, Eliason, & Merrifield, 1988; O'Dougherty, Nuechterlein, & Drew, 1984). To spot which brain regions play a role in ADHD, Martin Teicher and colleagues at the Malean Hospital in Belmont, Massachusetts, and Harvard Medical School in Boston (cited in Hagmann, 2000) found that a part of the striatum called putamen was much less active. Furthermore, putamen activity correlated with ADHD symptoms: the more severe the case, the lower the putamen activity. Several studies also showed that the prefrontal cortico-striatal network now appears that hereditary factors plays the largest role in the occurrence of ADHD symptom in children (Barkley, 1998). Moreover, the severe hyperactivity symptom is associated with the higher level of left relative regional cerebral blood flow (left rCBF) more than right relative regional cerebal blood flow (right rCBF). (Langleben, Austin, Krikorian, Ridlehuber, Goris, & Strauss, 2001). A recent study, however, also found that a decreased rCBF in the left dorsolateral prefrontal cortex (DLPFC) compared to the right DLPFC was a predictor of higher severity of clinical symptom expression and neuropsychological attention impairment (Spalletta, Pasini, Pau, Guido, Menghini, & Caltagirone, 2001).

Possible neurotransmitter dysfunction or imbalances have been proposed, resting chiefly on responses of ADHD children to differing drugs. Given the findings that normal children show a positive, albeit lesser, response to stimulants, evidence from drug responding by itself cannot be used to support a neurochemical abnormality in ADHD (Rapoport et al., 1978 cited in Barklry, 1998). Dopamine function had been studied in genetic involvement on ADHD (Dougherty, Bonab, Spencer, Rauch, Madras, & Fischman, 1999); specifically, associations on both dopamine D4 receptor gene and a variable number of tandem repeats (VNTR) the polymorphism of unknown function in the 3'untranslated region of the dopamine transporter gene (DAT1). However, one study (Todd, Jong, Lobos, Reich, Heath, & Neuman, 2001) fail to demonstrate any significant association or trend for association of any of the variable number of tandem repeats (VNTR) alleles with any of the variously defined ADHD subtypes. It seems to point to a selective deficiency in the availability of both dopamine and norepinephrine, but this evidence cannot be considered conclusive at this time (Barkley, 1998).

Complications occurring during pregnancy or at the time of delivery could also cause ADHD symptom (Barkley, 1998). A recent study found that newborns with very low birthweight (VLBW) were more vulnerable to psychiatric sequelae and especially to attention-deficit/hyperactivity disorder when they grew up (McGrath, Sullivan, Lester, & Oh, 2000; Nicola, Andrew, & Richard, 1997). However, a large-scale epidemiological studies have generally not found a strong association between pre- or perinatal adversity and symptoms of ADHD once other factors are taken into account, such as maternal smoking and alcohol use as well as socioeconomic disadvantage, all of which may predispose to perinatal adversity and hyperactivity (Goodman & Stevenson, 1989; Werner, Bierman. French, Simonian, Cornor,Smith, & Campbell, 1968).

2. Genetic Factors

Genetic factors may give rise to ADHD symptom. However, no evidence exists showing that ADHD is the result of abnormal chromosomal structures, as in Down syndrome, their fragility (as in fragile X), or extra chromosomal material, as in XXY syndrome. Children with such chromosomal abnormalities may show greater problems with attention, but such abnormalities are very uncommon in children with ADHD. By far, the greatest research evidence suggests that ADHD is highly heritable, making heredity one of the most well-substantiated etiologies for ADHD (Barkley, 1998). For a twin-sibling study has found that the covariation between hyperactivity and oppositional/conduct problems in both younger and older boys and girls was almost entirely attributable to genetic factors (Silberg, Rutter, Meyer, Maes, Hewitt, Simonoff, Pickles, & Loeber, 1996). However, Levy, Hay, McLaughlin, Wood, and Waldman (1996) investigated the behavior problems between four-to-twelve year old twins and siblings from 1938 families. Families were sent a questionnaire based on DSM-III-R criteria for ADHD, Oppositional Defiant Disorder (ODD), Conduct Disorder (CD), and Separation Anxiety (SA), which was validated by formal clinical interview. The questionnaire also included measures of speech and reading problems. They found significant differences between twins and siblings for ADHD symptoms, but not for symptoms of ODD, CD or SA. Twin and siblings differed significantly for gestational age, birth weight, speech and reading problems. While there was little evidence for birth weight or gestational age contributing to the difference in ADHD symptoms, there was a strong association between ADHD symptoms and speech and reading problems. Twin studies can also tell us as much about environmental contributions as they do about genetics factors affecting the expression of a trait (Faraone, 1996; Plomin, 1995). Moreover, nonshared enviroment factors (e.g. social environment, nongenetic biological factors) could be the result of differences in ADHD symptoms (Barkley, 1998).

3. Environment Toxins

The environment may play some role in individual differences or those influences within the psychological realm. As noted previously, variance in the expression of ADHD that maybe a result of environmental sources means all nongenetic sources more generally. These include pre-, peri-, and postnatal complications and malnutrition, diseases, trauma, and other neurologically compromising events that may occur during the development of the nervous system before and after birth (Barkley, 1998). Some studies found relationship to inattention and hyperactivity are prenatal exposure to alcohol and tobacco smoking of mother (Shaywitz, Cohen, & Shaywitz, 1980; Streissguth, Martin, Barr, Sandman, Kirchner, & Darby, 1984; Streissguth, Bookstein, Sampson, & Barr, 1995).

4. Psychosocial Factors

Willis and Lovaas (1977 cited in Barkley, 1998) claimed that hyperactive behavior was the result of poor stimulus control by maternal commands and that this poor regulation of behavior arose from poor parental management of the children. Others have also conjectured that ADHD results from difficulties in the parents' overstimulating approach to caring for and managing the child as well as parental psychological problems (Carlson, Jacobvitz, & Sroufe, 1995; Silverman & Ragusa, 1992). But these theories have not been clear in articulating just how deficits in behavioral inhibition and other cognitive deficits commonly associated with clinically diagnosed ADHD could arise from such social factors. Moreover, many of these studies proclaiming to have evidence of parental characteristics as potentially causative of ADHD did not use clinical diagnostic criteria to identify their children as ADHD; instead, they relied merely on elevated parental ratings of hyperactivity or laboratory demonstrations of distractibility to classify the children as ADHD (Carlson et al., 1995; Silverman & Ragusa, 1992).

It can be concluded that neurological and genetic factors make substantial contributions to symptoms of ADHD and the occurrence of the disorder. A variety of genetic and neurological etiologies (e.g. pregnancy and birth complication, acquired brain damage, toxins, infections, and genetic effects) can give rise to the disorder through some disturbance in a final common pathway in the nervous system. The condition can also be caused or exacerbated by pregnancy complications, exposure to toxins, or neurological disease. Social factors alone cannot be supported as causal of this disorder, but such factors may exacerbate the condition, contribute to its persistence, and, more likely, contribute to the forms of comorbid disorder associated with ADHD. Even so, environmental factors involving family and social adversity may still serve as exacerbating factors, determinants of comorbidity, and contributors to persistence of disorder over development (Barkley, 1998).

2. EEG Markers for Attention-Deficit/Hyperactivity Disorder

According to Sterman (Sterman, 2000), it was recently found that topographic quantitative EEG methods have disclosed several distinct patterns of abnormality in children with ADHD, and have provided improved guidelines for pharmacological treatment. From the review, the idea that some type of brain disturbance could be responsible for abnormalities in attention and hyperactivity in children actually arose from pathological finding and physiological theories related to an epidemic that spread through the city of Vienna in the early years of the 20^{th} century. AS we have seen, evidence of EEG abnormality was a possible marker for ADHD has existed for many years. Today, a growing number of modern scientific reports strongly support this conclusion. Recent papers, applying careful diagnostic criteria to the study of large groups of children, have shown conclusively that more than 90% of those with ADHD show quantitative EEG (QEEG) findings indicating disturbances in neurophysiological regulation (Chabot, Orgill, Crawford, Harris, & Serfontein, 1999; Hughes & John, 1999). Further, a convergence of EEG findings with brain imaging and genetic studies is providing compelling evidence that a more objective biological approach to the evaluation of ADHD and to the classification of ADHD subtypes is possible (Sterman, 2000).

Comparisons of carefully diagnosed children with ADHD with matched controls have disclosed a number of abnormal EEG patterns in this population, such as:

1. A localized excess of 4-8Hz theta activity in prefrontal, frontal, and sensorimotor cortex. This abnormality was facilitated during cognitive engagement (Mann, Lubar, Zimmerman, Miller, & Muenchen, 1992, Chabot et al., 1999).
2. A generalized excess of theta or slowed alpha activity in all cortical areas during all tests states, often exaggerated during task engagement. This excess is sometime, but not always, greatest in anterior cortical areas (Lubar, 1991; Mann et al., 1992).

3. A significant excess of normal alpha rhythm activity mostly in anterior cortical areas (Chabot et al., 1999).

4. A significant reduction of normal 12-20Hz rhythmic activity in the sensorimotor area (Known as Sensorimotor Rhythm, or SMR) associated with increased faster activity (Mann et al., 1992).

5. EEG hypercoherence between left and right frontal recording and between frontal/temporal regions (Chabot et al., 1999).

Based on a growing QEEG literature focused on ADHD, Sterman (2000) has identified three basic and sometimes overlapping patterns of QEEG abnormality in children with ADHD. The identifications were as follow:

2.1 Non-localized Slowing of EEG Rhythms in All States of Attention

Some children with ADHD show abnormally slowed EEG rhythmic activity under circumstances when non-ADHD children show the dominant 8-12Hz alpha rhythm. Chabot and Serfontein (1996) reported that 30% of their population of ADD/ADHD children displayed this EEG subtype. The abnormalities were typically generalized but most apparent at anterior cortical sites. It is possible, therefore, that some of the children with this EEG subtype may be experiencing delayed maturation of the neural pathways and neurotransmitter systems that control the various components of attention and behavior control (Satterfield, Schell, Backs, & Hidaka, 1984), and the development of eye movement control (Munoz, Hampton, Moore, & Armstrong, 1998 cited in Sterman, 2000). Their primary risk, however, arises from the psychosocial damage that can result from unrewarding family, peer, and social interaction. Additionally, the stigma and potential physiological side effects of the long-term use of stimulant medications can further complicate their development.

2.2 Abnormal Prefrontal and Frontal Slow Activity

A second, more common pattern is the highly coherent, slow activity seen in frontal and particularly pre-frontal areas. This abnormal activity is clearly facilitated with attention and task engagement. Chabot and Serfontein (1996) reported that approximately half of the population of 407 children with ADD that they evaluated fell into this subtype. This pattern is most often associated behaviorally with varying degrees of hyperactivity, disturbed affect and social behavior, and impulsive control.

2.3 Increased Central and Parietal Alpha Activity

This pattern may take several different forms. It can be relatively limited to central cortex, and suppressed during attentional states, with or without motor activity. In contrast to the children described previously, these children are often bright, playful, friendly, and very active. They can have terrible handwriting. However, they can respond to instructions and become very attentive if motivated.

Additionally, advances in EEG technology have given rise to a promising alternative behavioral treatment for ADD or ADHD called neurofeedback. Quantitative EEG assessment is considered essential in relation to this treatment as well.

3. Operant Conditioning

This study attempted to use one concept of B. F. Skinner's operant conditioning to help research participants increase their attentional behavior while doing mathematics activities. From his theory, Skinner stresses the importance of discovering functional relations (or, "cause-and-effect connections") between environmental conditions and behaviors. To Skinner, the study of emitted responses and their consequences constitutes the essential subject matter of psychology. Whereas respondent behavior is under the direct control of its antecedents, operant behavior is initially produced by an organism in the absence of any easily identifiable eliciting stimulus and is controlled by its consequences (the effects that it has). The most important consequence in Skinner's analysis of behavior is reinforcement (Cloninger, 2000). The strengthening of behavior results from reinforcement, i.e., conditioning. In operant conditioning Skinner "strengthens" an operant in the sense of making a response more probable or frequent (Skinner, 1953).

Skinner indicated that there are two types of reinforcement—positive reinforcement and negative reinforcement—that can occur as a consequence of behavior (Cloninger, 2000). Reinforcement has two effects—it strengthens behavior and generates "feeling". Sometimes reinforcement could reduce a state of deprivation (Skinner, 1953). The present study used only positive reinforcement. Positive reinforcement involves introducing or adding a stimulus after the individual performed the behavior. As we have seen, this consequence typically is something the person wants or finds pleasant or satisfying (Sarafino, 1996). For example, a response may be positively reinforced if the consequence is obtaining food, water, sexual contact, money, or praise (Skinner, 1953; Cloninger, 2000). Positive reinforcement is a consequence that always strengthens behavior.

Because positive reinforcement can have a very powerful impact on what people do, we need to know what kinds of positive reinforcers can be used to strengthen behavior (Sarafino, 1996). Some positive reinforcers are:

1. **Tangible and Consumable Rewards** Tangible rewards refer to material objects we can perceive, such as toys, clothing, or musical recording, and consumable rewards refer to things we can eat or drink, such as candy, fruit, or soft drinks. Tangible and consumable rewards have a strong influence on our everyday actions and include both unconditioned and conditioned reinforcers.

2. **Activities** We can use activities as reinforcers to increase behavior, such as by using the opportunity to play a video game as a reward for child when he or she finishes doing homework. This rule is known as the ***Premack principle***. The important implication of the Premack principle is that we can identify existing and potential reinforcers by looking for high-probability behaviors in people's naturally occurring activities, as we do in functional analyses. This approach is usually effective and easy to use, but deciding how to assess and compare different behaviors can be tricky.

3. **Social Reinforcers** Social reinforcers are consequences of behavior involving interpersonal acts, such as smiling, nodding, praising, and giving attention or affectionate touches. These acts can be given directly to the person or indirectly, such as in a letter of appreciation or commendation at work. Social reinforcers usually are

very subtle in our everyday lives, but they have very powerful effects on people's actions and often strengthen undersirable behavior without our realizing it.

4. **Tokens** Tokens are symbolic rewards that represent or resemble money because they can buy or be traded for goods or privileges. The tokens themselves can be tickets, small chips or buttons, check marks or stars on a chart, or points recorded in a log. The goods or privileges are called backup reinforcers, and are generally some form of tangible, consumable, activity, or social rewards.

5. **Covert Reinforcers** Covert reinforcers are imaginary consequences individuals experience for their behaviors. Covert reinforcers are different from other rewards because they are not actually experienced. It would seem unlikely that they would have as much reward value as their actual counterparts, but they have the advantage of always being available and easy to use. Like all other rewards, covert reinforcers work best if they are invoked soon after the target behavior.

For this study, reinforcement was provided immediately after target skills were elicited, as recommended by Skinner. Token reinforcers were thus administered immediately after the participants reached their behavioral goal (attentional behavior). Participants received reinforcers on a fixed interval reinforcement schedule (FI) after researcher-set behavioral goals were achieved.

As mentioned earlier, this study used EEG-biofeedback to provide information for children with ADHD. This biofeedback technique is comparable to reinforcement technique because the feedback information helps participants be aware of their performance and be able to increase their target behaviors. Biofeedback lets the people know the result of what they are doing immediately after they performed their behaviors. Biofeedback helps people gain voluntary control over body processes by giving them continuous and very specific information about the current functioning of a physiological process (Sarafino, 1996). In the case of ADHD children, acknowlegement of EEG biofeedback helps them control their own behaviors. When they show more theta wave than beta wave while doing activities, the EEG biofeedback apparatus would inform the children with audible signals. These audible signals will make the children aware of their inappropriate behaviors, such as daydreaming or inattentive behaviors. The children, then, can control their inappropriate behaviors and increase their attentional behaviors by focusing on their mathematics activities.

Related Research

Neurotherapy or EEG biofeedback has become an alternative habilitative treatment for ADD/ADHD (Anderson, Barabasz, Barabasz, & Warner, 2000). Currently, there are over 300 organizations using EEG neurofeedback on the treatment of ADHD (Lubar, 1995). In this treatment, the slow EEG theta waves, typical of the wandering mind, are inhibited and the faster EEG beta waves, associated with learning and vigilance are enhanced through feedback training (Anderson et al., 2000). Pope and Bogart (1996) note that training includes providing real-time beta-theta information to show the children with ADHD how well they are producing attention- and concentration-related brainwave activity. The neurofeedback training may be associated with better learning and better attentive mechanisms. The training was also used to improve cognitive and psychophysiological functioning (Lubar, 1991; Lubar et al., 1995). Lubar and Shouse (1977 cited in Barabasz & Barabasz, 2000) treated a group of children with ADD with the EEG biofeedback using a standard protocol (reinforce beta and inhibit theta). Using an A-B-A design, the protocol was then switched to inhibit beta and enhance theta. The children, parents, and teachers were kept masked regarding the switch, but within two weeks they began reporting that children's behaviors and attentional skills were deteriorating. Returning to the standard protocol at 4 weeks the children, parents, and teachers noted resumption of academic and behavioral improvement. Lubar et al. (1995) presented data on 19 participants in an intensive summer neurofeedback training program. Patients were given daily one hour training sesesions for 8-10 weeks, with the goal of accomplishing 40 training sessions during summer months. Neurofeedback was given during two 5 minute on screen period, follow by a 5-minute reading and 5-minute listening periods during which auditory feedback was given simultaneous with the cognitive task. Outcome measures were theta amplitude, TOVA (the Test of Variables of Attention) continuos performance test, WISC-R and Attention Deficit Disorder Evaluation Scale (ADDES). Twelve of the 19 patients showed significant lowering of theta across sessions. These 12 showed improvement on three TOVA scales on average, while the group that showed no lowering of theta improved on 1.5 TOVA scales on average. Pre-post ADDES showed significant improvement ($p<.001$) for inattention, hyperactivity, and impulsivity for all patients. The criticism that such improvement is merely the result of parents reporting improvement simply because of the length and intensity of treatment is not intuitive. WISC-R tests were administered post-trearment by an independent neuropsychologist for 10 children who had WISC-R data from approximately 2 years prior to treatment. All children in this group showed reduction in theta activity during the course of their neurotherapy. Significant improvement ($p<.05$) in Verbal, Performance and Full Scale IQ were found.

Linden, Habib, and Radojavic (1996) examined eighteen children with ADHD ranging in ages from 5 through 15. The participants were randomly assigned to one of two conditions. The experimental condition consisted of 40 to 45-minute sessions of training enhancing beta activity and suppressing theta activity, spaced over six months. The control condition, waiting list group, received no EEG biofeedback. All participants had no other psychological treatment or medication. Participants were measured at pretreatment and at post-treatment on an IQ test and parent behavior rating scales for inattention, hyperactivity, and aggressive/defiant (oppositional) behaviors. At post-treatment the experimental group demonstrated a significant increase on the K-Bit IQ Composite as compared to the control group. The experimental group also significantly reduced inattentive behavior as rated by parents. Moreover, Warner et al. (2000) has examined eighteen children and one young adult who met the DSM-IV diagnostic criteria for ADHD by using Barabasz' alert hypnosis instantaneous neuronal activation procedure (INAP) as an adjunct to neurotherapy. Participants received visual and auditory presentation of their EEG in real time on a computer screen and stereo speaker. Participants were instructed to increase their beta waves and decrease their theta waves. The participants' behavior were measured by using the Attention Deficit Disorder Evaluation Scale—Home Version. They found that after the treatment protocol, parents reported fewer incidents of inattentive, impulsive, and hyperactive behavior. Ratings provided by the therapist also suggested improvement in the self-monitoring behaviors of the majority of participants. Another study reported similar improvement on WISC-III Digit span and TOVA Inattention and Hyperactivity scales in five to six students (Boyd & Campbell, 1998). The students received sensory-motor rhythm (SMR) training during twenty 30-minute sessions conducted in a school environment may prove daunting during the training. Time commitment, equipmnent issues can arise. Nonetheless, out-of-clinic training is an interesting possibility.

Further, some research compared the efficacy between EEG biofeedback and other approach. A recent study compared the treatment program with EEG biofeedback and psychostimulants in treating ADHD symptoms (Rossiter & La Vaque,1995). To examine the attentive behavior of both groups, the Test of Variables of Attention (TOVA) was administered pre and post treatment. Results indicated that EEG biofeedback and methylphenidate groups improved on measures of inattention, impulsivity, information processing, and variability, but did not differ on TOVA change scores. However, Lubar, Swartwood, Swartwood, and Timmerman (1995) reported a series of studies further defining the QEEG and auditory event-related potential (AEP) characteristics of ADHD, methylphenidate effects and the efficacy of neurotherapy. The AEP and methylphenidate literatures are complex. Briefly, these authors found no significant effects of Ritalin and theta/beta ratios.

As previously noted, EEG biofeedback training was not very effective when used alone. Therefore, we should combine EEG biofeedback treatment with other techniques. It appears to be promising for reducing some of the behavioral symptoms (Lee, 1991). This study will use EEG biofeedback with positive reinforcement to reduce inattentive behavior without medication.

Positive reinforcement is a behavioral approach that have no side effects on people with ADHD. It is also effective for children with ADHD who do not respond to psychostimulants (Pelham, Jr. 1991). Numerous studies have found that positive reinforcement significantly improved ADHD children's behaviors (Abramowitz & O'Leary, 1991; Gordon, Thomason, Cooper, & Ivers, 1991). Twardosz and Sawaj (1972) found that using positive reinforcement increased sitting in a hyperactive, retarded boy in a remedial preschool. Freibergs and Douglas (1969) conducted a study that compared the performances of ADHD and normal control children on a concept-learning task under either continuous, partial, or delayed (also continuous) reinforcement conditions. They found that both ADHD and control participants performed significantly better under continuous reinforcement than under partial reinforcement (PR). However, the children with ADHD performed less well than controls under conditions of PR. Moreover, Parry and Douglas (1983) conducted another study concerning concept identification in children with ADHD under three reward conditions: continuous, standard, and partial rewards. They found improvement of child attentional behavior in three of reward conditions. Barber and colleagues (Barber, Milich, & Welsh, 1996) examined the effects of reinforcement schedule and task difficulty on the performance of ADHD and normal control boys on a learning task. They found that the performance of both the boys with ADHD and control boys was adversely affected by partial-reinforcement in the related-word task. In the unrelated-word task, the performance of both groups was optimized under the continuous reinforcement condition. Children with ADHD tended to show a "helpless" pattern of behavior, as opposed to a "mastery-oriented" pattern, and may have an unrealistically positive view of their own competence. Other findings indicated that children with ADHD tended to use memory strategies characteristic of younger children .

One technique using positive reinforcement is self-reinforcement. Abikoff (1985) report that when a single investigation included both cognitive training and self-reinforcement, the self-reinforcement condition had been the one that had a positive impact on the targeted behaviors. Ajibola and Clement (1995) examined six boys aged 9 to 12 years who attended a tutoring class focusing on reading for 30 minutes each morning. The investigators employed a modified Latin-square design in which each child began with a 5-day baseline phase followed by six 10-day treatment phases that used drug placebo, noncontingent reinfocers, 0.3 mg/kg methylphenidate, 0.7 mg/kg methylphenidate, and self-reinforcement in various combinations. They found that drug placebo and noncontingent reinforcers had no systematic impact. Methylphenidate had differential effects across the recorded behaviors. Self-reinforcement improved the target behavior. The combined effects of methylphenidate and self-reinforcement on academic performance were greater than either of the treatments given alone. Moreover, many studies found that a combination of self-reinforcement and another techniques (i.e., shaping) is more effective than using either alone (Calson, Pelham, Milich, & Dixon, 1992; Hinshaw, Henkere, & Whalen, 1984). Using self-reinforcement training also helped people reduce depression because it could help them to learn to reward themselves. This skill perhaps increases one's resistance to the effects of environment changes in sources of reinforcement by providing the individual with a self-controlled source of pleasurable events, thus rendering the individual less dependent upon externally controlled sources of pleasure (Heiby, Ozaki, & Campos, 1984). However, Anderson, Clement, and Oettinger (1981) compared the effects of methylphenidate and training in self-reinforcement on sustained attention as measured by the Children Checking Test. Across the 12 boys who participated in the study, methylphenidate was more helpful than training in self-control, but the investigators had failed to ensure that their subjects actually carried out the prescribed self-reinforcement procedures in the treatment setting.

Positive reinforcement not only affects attentional behavior (Kazdin & Mascitelli, 1980) but also disruptive behavior (Kaufman & O'Leary, 1972; Kazdin, 1980). It also is effective on other problem behaviors or symptoms. Iwata and Bailey (1974) compared the effects of reward and cost token procedures on the social and academic behavior of two groups of elementary special-education students by using a reversal design. Behavioral observations of three target subjects in each group revealed that both procedures were about equally effective in reducing rule violations and off-task behaviors (Iwata & Bailey, 1974). Atkeson and Forehand (1979) evaluated the use of a home-base reinforcement program to modify disruptive and academic behaviors in the classroom. They found positive improvement of those behaviors of participants. Moreover, Thompson and Iwata (2000) compared the effects of direct and indirect reinforcement contingencies on the performance of 6 individual with profound developmental disabilities. Under both contingencies, completion of identical tasks (opening one of several types of containers) produced access to identical reinforcers. Under the direct contingency, the reinforcer was placed inside the container to be opened; under the indirect contingency, the therapist held the reinforcer and delivered it to the participant upon task completion. They found that one participant immediately performed the task at 100% accuracy under both contingencies. Three participants showed either more immediate or larger improvements in performance under the direct contingency. The remaining 2 participants showed improved performance only under the direct reinforcement contingency (e.g., reaching for the reinforcer instead of performing the task) which provided some evidence that these behaviors may have interfered with task performance and that their occurrence was a function of differential stimulus control.

Purpose of the study

The objective of this research was to examine how EEG biofeedback and positive reinforcement affects the attentional behavior of children with ADHD while they do mathematics activities.

Research Hypothesis

EEG biofeedback and positive reinforcement could improve the attentional behavior of children with ADHD while they perform mathematics activities.

Limitations of the Study

1. *The insensitivity of the instrument*. The EEG-biofeedback instrument used in this study was a two-channel type and could not provide precise brainwave information for data analysis. The instrument could only provide an average brainwave of the whole brain. Besides, the instrument was not sensitive in extracting brainwave activity from the noise signals. Thus, the information received from this instrument was a mix-up signals of the brain activity and noise.

2. *The relatively short treatment duration*. In order to have a successful behavior intervention, a long duration of treatment phase is required. However, the availability of time that parents allowed their ADHD children to participate in the study was about 30 days. Thus, children had only 20 days to attend the treatment phase. The short duration of treatment that children received in the study just about to start enhancing their beta/theta brainwave ratio and improving their attentional behaviors. These effects, however, were not big enough to statistically demonstrate a significant difference from baseline phase. A longer duration of treatment phase of at least 40 days (linden et al., 1996; Lubar, 1995) was suggested.

Operational Definition of Terms

Attention-Deficit/Hyperactivity Disorder (ADHD) is characterized by inattention, hyperactivity, and impulsivity. The diagnostic criterion of ADHD in this study was from three sources; 1) physician's diagnosis of ADHD, 2) Parental rating by parents version of the ADHD-Symptom Inventory (ADHD-SI) and Corners' ADHD/DSM-IV Scales (CADS), and 3) Teacher's rating by teacher version of the ADHD-Symptom Inventory (ADHD-SI) and Corners' ADHD/DSM-IV Scales (CADS). To be recruited for the study, the diagnosis from all three sources had to agree. Otherwise, he/she was not recruited for the study.

Brainwaves. There are five main frequency “brainwaves” comprising the usual spectrum of EEG activity. These are gamma, beta, alpha, theta, and delta. (Craib & Perry, 1975). The brainwaves of interest in this study, however, were beta and theta and assessed by EEG-biofeedback Instrument (Focus Technology, 1996).

Attentional Behavior on Mathematics Activities. In this study, participant who had attentional behavior must perform at least one of the following behaviors while attending mathematics activities;

1. Look at each mathematics problem
2. Read each mathematics problem
3. Solve the mathematics problem by calculating on paper or rehearsing multiplication table
4. Write the answers on an answer sheet

Benefits of the study

1. To demonstrate that EEG biofeedback and positive reinforcement can Improve the attentional behaviors of ADHD children.
2. To present an alternative treatment for children with ADHD.
3. To empower the parents of ADHD children participated in the study in managing their own children.

Chapter 2
Methodology

This study examined the hypothesis that EEG-Biofeedback and positive reinforcement could improve the attentional behaviors of 9.5 to 10.5 year-old children with ADHD. The participants consisted of six children with ADHD (inattentive type). All participants were recruited from the following Bangkok elementary schools: two students from St. Dominic's, a private Catholic school; two students from Chulalongkorn University Demonstration School, a public school; and two students from Plubplachai School, a public school. The six children with ADHD were randomly assigned into experimental and control groups. An ABA control group research design was applied. The variables of the study were as follows:

1. Independent Variables:
   - 1.1 Positive reinforcement for attentional behaviors.
   - 1.2 An audible signal (silence from the EEG-Biofeedback instrument) to the participant whenever he/she shows high theta brainwave activity.
2. Dependent Variables:
   - 2.1 Beta and theta brainwaves
   - 2.2 Child attentional behaviors

Participants

One girl and five boys aged between 9.5 to 10.5 years old participated in the study. All participants were independently diagnosed as children with ADHD by a physician with the inattentive form of DSM-IV Attention-Deficit Hyperactivity Disorder. None of the participants were diagnosed with Learning Disability (LD). To confirm diagnoses, parents and teachers of the participants were asked to complete an ADHD-Symptom Inventory (ADHD-SI; Cox et al., 1998), and the parent and teacher versions of the Conners' ADHD/DSM-IV Scales (CADS; Conner, 2000). Results indicated that all the children had ADHD. All ADHD participants were free of psychostimulant medication over the preceding six months. After children with ADHD were identified, they and their parents were asked to meet the researcher to discuss and clarify project procedures, and to sign consent forms. Children with ADHD were randomly assigned into experimental and control groups comprising 3 children in each group.

Instruments

1. Questionnaire Assessment of ADHD
   A. ADHD-Symptom Inventory (parents and teacher versions) (ADHD-SI; Cox et al., 1998)
   B. Corners' ADHD/DSM-IV Scales (parents and teacher versions) (CADS; Conner, 2000).

The researcher translated these two questionnaires and validated the accuracy of the translation by consultation with 3 psychology professors at Chulalongkorn University. Both parent and teacher versions of ADHD-SI and CADS were tried out in a pilot study of 30 ADHD children from Psychiatry department of Chulalongkorn Hospital. The internal consistency of test items on each questionnaire were computed with coefficient alpha (α.). For the ADHD-SI, the coefficient alpha for the Teacher Version was 0.86, and for the Parent Version was 0.80. For the CADS , the coefficient alpha for the Teacher Version was 0.82, and for the Parent Version was, 0.87.

Inter-rater reliability of the instrument was assessed by percent agreement between parent and teacher in diagnosing each child in the pilot study. The percent agreement between parent and teacher of both ADHD-SI and CADS were 100% (see appendix D for details).

2. EEG-Biofeedback Assessment of Attention.

A two-channel EEG-Biofeedback instrument (Focus Technology Co.) with bipolar electrodes, Cz ground, and linked-ear reference electrodes were used to gather beta and theta brainwaves. The active electrode was placed at Cz—a central location at the crown of the head.

3. Behavioral Assessment of Attention.

Child attentional behaviors were observed while they were doing mathematical tasks and recorded by using a four items behavior checklist (see appendix E). Participants who had attentional behavior must perform at least one of the following behaviors while attending mathematics activities;

1. Look at each mathematics problem
2. Read each mathematics problem
3. Solve the mathematics problem by calculating on paper or rehearsing multiplication table
4. Write the answers on an answer sheet

The observers were blind to the treatment status of the children. Ten mathematical tasks (see the example in appendix A), varying in difficulties, were used in this study. Five mathematics tasks were used during the baseline phase and five different tasks were added during treatment. Variation in the difficulty of the mathematical tasks had previously been assessed in a separate study on thirty-five 9.5 to 10.5 year-old students from Chulalongkorn Demonstration School. Item with difficulty was calculated. Item difficulty ranged between 0.40-0.80 (see appendix D) was selected and used in this study.

Procedure

Preparations. Prior to the experiment, participants were identified and randomly assigned into control and experimental groups. Parents of participants in the control group were told their children would be assessed for 27 sessions without treatment, and thereafter receive full treatment. The researcher then visited participants' homes two times a week for two weeks to develop rapport with the child and family. Participant families were also invited to visit the Faculty of Psychology laboratory three days before treatment began.

The researcher also trained three psychology graduate students to assist in the experiment and to observe the attentional behaviors of the participants. Two of the assistants observed and recorded participant attentional behaviors while the third signaled the researcher by turning on a red light to give a reinforcer (a sticker) to the participants when participants performed attentional behaviors. Both observers were trained until they reached a 90% inter-rater agreement criterion for three consecutive trials during the training sessions.

Moreover, the researcher assessed a particular reinforcer for each participant in the experimental group by asking **what reward he/she would like to have if he/she could reach the treatment goal**. The value of reward each child proposed should not exceed 200 Baht as summarized in table 1.

Table 1 Rewards of the participants in the experimental group

Child	Reward	Baht
A	2 CD-Games	160
B	A headband	200
C	A pocketbook story	135
	Total	495

Laboratory Setting. The laboratory contained a one-way mirror and was equipped with a computer monitor; a speaker; a 2x3 feet table where the researcher and participant sat across from each other; and a box with electrodes and EEG 10-20 gel. In the adjacent room, behind the one-way mirror, was a computer on a table, a chair for a research assistant, a red bulb for signaling, a video recorder, and a tape player (see appendix H).

Experimental Procedure. The experiment was divided into 3 phases—baseline, treatment, and follow-up phases.

I. Baseline Phase.

The objective of this phase was to collect brainwave activity (beta and theta brainwaves) and to assess child attentional behaviors while doing mathematics tasks. The baseline phase consisted of 5 sessions, 1 session each day for the 5 consecutive days. For each baseline session, participants had to perform mathematics tasks for 30 minutes. Interval recording was used to record child attentional behaviors. Child attentional behaviors were observed for 20 seconds and recorded for 10 seconds in each interval for 30 minutes. Therefore, there were 60 intervals total in 30 minutes for each session. To allow observers to focus completely on child behaviors and not on stopwatches, timing of the observation intervals was set by a tape recording of the researcher stating, "observe" and "record" as mention above. Inter-observer reliability was computed between the two observers who observed all child attentional behaviors through the one-way mirror. All participants in the experimental, and control groups completed 5 baseline sessions. The researcher asked 3 normal children to do the same mathematical tasks and recorded their attentional behaviors for 5 sessions. Their beta and theta brainwaves were also recorded. After that the researcher calculated the mean of normal child attentional behaviors and used those averages as the criterion for the children with ADHD in the experimental group. The goal of the experiment was to increase the attentional behavior of the participants in the experimental group while performing mathematics tasks not less than 80% of this criterion.

The detailed instructions of the baseline procedure are as followed:

1. *Preparation of the EEG instrument.* The theta threshold of the EEG-Biofeedback was set at the level of 5 micro volt (m.v.). Participants who could inhibit their theta level to less than 5 m.v. would not receive any audible signal from the EEG instrument. Participants who could not inhibit their theta level to 5 m.v., however, would

receive an audible signal of a very loud, aversive, jack-hammer-like noise (Othmer protocal; Othmer, Othmer, & Marks, 1991).

2. *Preparation of Participants.* Participants were then brought into the laboratory, shown a selection of five mathematic tasks, and asked to choose one. Then the researcher removed the unselected tasks and gave him a pencil and an eraser. Participants were then asked to sit upright, told not to move excessively, and explained the trial procedure— *"While you are doing math for 30 minutes, I would like to test your brain waves so you know how much brainwave power you have."*

   Permission to place electrodes on the participant's head was obtained. (see Appendix C for detailed verbal instructions). The crown of the participant's head (Cz point) was cleaned with Nuprep gel. Electrodes were place in a bipolar pattern, with the large-area electrode in a monopolar configuaration at Cz, and with an ear-reference and arm grounding. A 10-20 electrode gel was used for maximum electrical conduction and adhesion to the child's Cz point and the back of his/her ear. Electrodes were placed in this exact pattern in all phases of the study.

1.3 Data Recording. Data recording began when the child started working on his/her mathematics task. An observation sheet was used to record child attentional behaviors (see an example in the appendix E). The observers observed child attentional behaviors for 20 seconds and recorded for 10 seconds in each interval, total 60 intervals for each session.

1.2 Treatment Phase.

A total of 20 treatment sessions were done for each ADHD participant. Each child received one 30-minute treatment session on a weekday. The treatment sessions were divided into two sub-phases: sub-phase1 treatment by the researcher in the laboratory only, for the first 10 sessions and sub-phase 2 which contained two consecutive stages: (a) treatment in the laboratory, and in the child's home by the researcher, for 5 sessions; followed by (b) treatment by the researcher in the laboratory in the morning, and by the child's parents at home in the evening, for the last 5 sessions. For the experimental group, treatment ended when each participant completed the 20 treatment sessions.

<u>Sub-Phase 1: Laboratory-based Treatment.</u> (10 sessions)

Treatment for the first 10 sessions was conducted only in the laboratory. In general, the procedure in this sub-phase was identical to the baseline procedure described above, except that 1) a new 5 series of mathematical tasks were added and used and 2) reinforcement for the child was now contingent on their attentional behaviors.

On the first day of treatment, the children were informed about their attentional behaviors during the baseline phase. They were told that they would be reinforced only if they could improve their performance by 15% of their baseline performances. The participants were also instructed: *"The best way to increase your brainwave power is not to move around too much, and to pay attention to your activities. If you do not concentrate enough, a voice from the EEG machine will warn you. So, try to stop the voice by paying more attention to your task."* Whenever a child improved attentional behaviors up to 15% of his/her baseline performance, a research assistant, sitting behind a one-way mirror, turned on a red light to signal the researcher to place ONE sticker beside the child's name on the reinforcement board. Each child could get up to 15-20 stickers a day if he/she kept performing attentional behaviors most of the time during a 30-minute session.

The criterion for 15% performance improvement over baseline was set by having an average baseline duration (minute) of each child's attentional behaviors and then calculating 15% more time as being the first criterion. For example, if the average baseline was 1 minute, then the 15% improvement over baseline must be 1 minute 26 seconds. If the participant could sustain his/her attentional behavior at the first criterion level continuously for 3 days, then, the researcher increased the second criterion to be15% more than the first one. The second criterion would be used for the following days. If the child can sustain his/her attentional behavior for this second criterion level continuously for three days, the third criterion would be set and so on. In summary, the criterion setup would be 15% more of the earlier criterion and would be used for each three-successive-day period.

For example

Baseline	=	1 minute
1st criterion	=	1 minute 26 seconds
2nd criterion	=	2 minute 05 seconds
3rd criterion	=	2 minute 40 seconds
		etc.

The criterion were set as described, and the total of 7 criterions were set for the whole treatment phase of all participants.

Participants who collected 30 stickers on the reinforcement board received a "Summoner Card", a popular children's picture card. When a child earned 10 Summoner cards, or when their attentional behaviors reached or exceeded the 80% of criterion set up by researcher which collected from the normal children for 5 sessions, they were allowed to select a toy worth 200 Baht.

If a child could not attain his/her goal, reinforcement conditions were then adjusted by decreasing the improvement percentage goal.

For example, if a participant could not reach his/her 15% above-baseline goal, it was reduced to 10% of his/her baseline performance. If this participant then sustained his attentive behavior at the reduced 10% level for 3 sessions, his goal would then be revised upwards again to 15%.

In case that some children could reach 80% of performance goal or criterion before the treatment sessions were ended. The treatment still went on until those children received completely 20 treatment sessions.

<u>Sub-Phase 2: Partial Laboratory-based and Partial Home-based Treatment.</u> (10 sessions)

The objective of these sessions was to generalize the child attentional behaviors into their domestic lives. As mentioned earlier, this sub-phase contained two stages:

Stage-A: both treatments in the laboratory and in the child's home were done by *the researcher* for the first 5 sessions; followed by

Stage-B: treatments by the researcher in the laboratory, and by the child's *parents* at home, for the last 5 sessions.

Each home-based treatment session, whether by the researcher or a child's parents, was 30 minutes.

Specific details of the home-based treatment were;

1. The researcher met the child's parents at their home in the evening, asked them to observe their child's performance, and gave them a training of what to do.
2. The researcher chose a room with a table as the training room and invited the child and his mother or father to attend the session. The child's mother or father sat near the table and the researcher sat next to the child. The researcher asked the child to choose one mathematics lesson from 5 different mathematics lessons. After the child made his/her

selection, the researcher asked him/her to rehearse how he/she previously increased his/her "brain wave power" in the laboratory. If the child accurately remembered the proper method, his/her treatment would resume; if he/she could not, the method was re-explained to him/her.

3. The researcher then asked the child to behave as if he/she was doing his/her mathematics lesson in the laboratory. He/She was reminded of the last 15% improvement criterion used in laboratory treatment and sticker he/she would receive. The researcher, then, presented his/her collection card and motivated the child to earn more stickers for the final reward.
4. The child was then asked to begin working on the mathematics activity, and the researcher started timing the session and observing the child's behavior.
5. When the child reached his behavioral goal for the 15% criterion, a sticker was placed on his card, and the researcher praised his behavior by saying "well done", "very good", or "excellent".
6. After the first 30-minute session of home-based treatment was finished, the researcher taught the parents to use the same reinforcement methods used in the study. After that, the parents were asked to observe the researcher's treatment for all 4 remaining sessions.
7. After the researcher finished her 5 sessions of home-based treatment, the parents would perform the remaing 5 sessions of home-based treatment by themselves. The researcher observed the parents during their first 3 sessions to ensure the correct treatment. Other additional reinforcements (more

than the sticker used in the study) that parents might offer to the child were allowed during these parents' sessions.

1.3. Follow-up Phase. (2 sessions)

One week after the treatment phase, each child in the control and experimental groups received two additional sessions of EEG-biofeedback. The attentional behaviors were also observed during this 2-session phase. Each follow-up session was done one week apart. During the follow-up phase, no reinforcers were used.

Chapter 3
Results

The purpose of this study was to examine the hypothesis that EEG-biofeedback and positive reinforcement could improve the attentional behaviors of 9.5 to 10.5 year-old children with ADHD. An ABA control group research design was applied. The study comprised 27 total sessions which included 5 Baseline, 20 Treatment, and 2 Followed-up. Child attentional behaviors and beta/theta brainwaves were collected for the whole study. However, each participant in the control group did not participate 7 times during treatment sessions in separate occasion. It means that 7 data points for each child in the control group would be missed for the data analysis. After that the researcher calculated means and standard deviation of the child attentional behaviors for both experimental and control groups in each phase of the study. Then, means and standard deviation of attentional behaviors during baseline and treatment phases for the experimental and control groups were compared by using t-tests. For beta and theta brainwaves, the researcher calculated the ratio of beta and theta brainwaves. Mean and standard deviation during baseline and treatment phases of experimental and control groups were used to compare the beta/theta brainwaves ratio by using t-test. The results of this study are presented as follows:

1. Number of intervals of attentional behaviors of normal children

For each session, participants had to perform mathematics tasks for 30 minutes. Interval recording was used to record child attentional behaviors. Child attentional behaviors were observed for 20 seconds and recorded for 10 seconds in each interval for 30 minutes. Therefore, there were 60 intervals total in 30 minutes for each session.

The data showed that mean of intervals of attentional behaviors of Child 1 was 53.40 intervals, Child 2 was 55.80 intervals, and Child 3 was 52.80 intervals. The total mean of intervals of attentional behaviors was 54.00 intervals.

Table2 Number of intervals of attentional behaviors of normal children

Child	Day 1	Day 2	Day 3	Day 4	Day 5	means
1	58	52	54	50	53	53.40
2	59	58	56	52	54	55.80
3	58	55	52	50	49	52.80
Total means						54.00

2. Attentional behaviors during the Baseline Phase

The independent-samples t-test was conducted to compare experimental and control groups attentional behaviors during the Baseline phase. There was no significant difference in attentional behaviors for experimental group (M=7.266 intervals, SD=6.435, Maximum = 30 intervals), and control group (M=9.198 intervals, SD=10.970, Maximum = 20 intervals). The magnitude of the differences in the mean was very small (eta squared= .014) (see Table 3)

Table 3 Results of the Independent-Sample t-test for Attentional behaviors during the Baseline Phase

Group	n*	Means	SD	df	t
Experimental	5	7.266	6.453	8	0.171
Control	5	9.198	10.970		

** Note n= numbers of session*

3. T-test table for Attentional behaviors during the Treatment Phase

The independent-samples t-test was conducted to compare the attentional behaviors of experimental and control groups on Treatment phase. Attentional behaviors between experimental (M=48.017intervals, SD=4.852, Maximum = 60 intervals), and control groups (M=0.158 intervals, SD=0.340, Maximum = 2 intervals) were statistically significant, t(38)=44.009, p<.05. The magnitude of the differences in the mean was very large (eta squared= .98). (see Table 4)

Table 4 Results of Independent-Sample t-test for Attentional behaviors on Treatment Phase

Group	n**	means	SD	df	T
Experimental	20	48.017	4.852	38	44.009*
Control	20	0.158	0.340		

*p<.05

*** Note n= numbers of session*

4. Mean and percentage table for intervals of attentional behaviors during treatment phase ofexperimental group compared with the criterion of normal children.

The data showed that the participants in experimental group could perform the attentional behaviors over than 80% of criterion level of the normal children.

Table 5 Means and percentages of attentional behaviors of paricipants in experimental group compared with normal children.

Groups	Means	Percentages
Normal	54.00	100
Experimental	48.017	88.89

The table showed participants' means and percentages of intervals of attentional behavior in both experimental and normal groups. The mean of normal children is 54 intervals and the mean of participants in experimental group is 48.017 intervals. It showed that the participants in experimental group could reach the 88.89% criterion level of normal children.

The attentional behaviors data of each participant in experimental and control groups are shown in figure 1-7

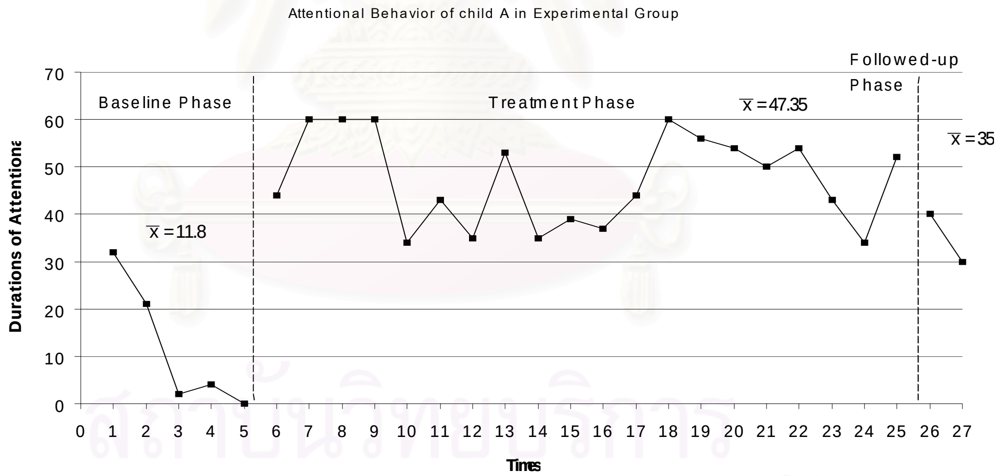


Fig.1 Attentional behaviors data of child A in experimental group. The mean of attentional behaviors on Baseline phase was 11.8, the mean on Treatment phase was 47.35 and the mean on Followed-Up phase was 35 intervals.

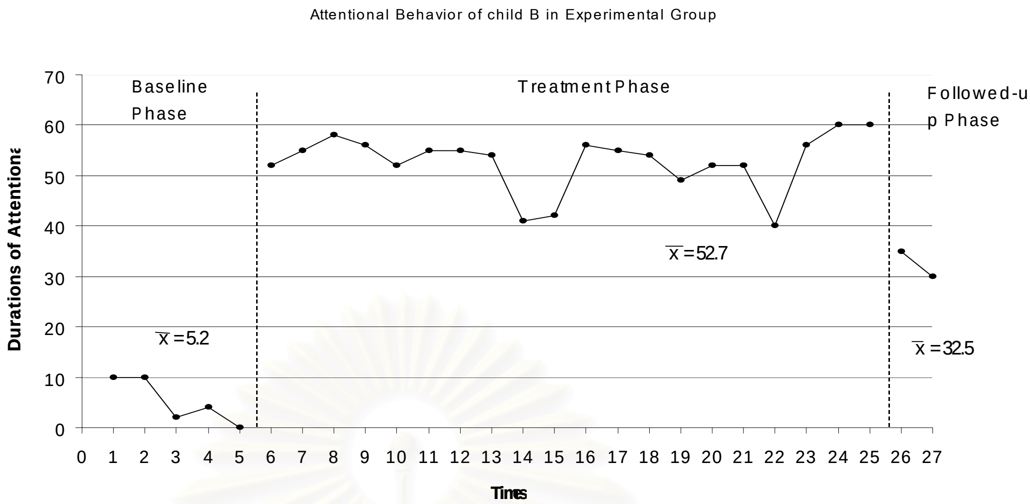


Fig.2 Attentional behaviors data of child B in experimental group. The mean of attentional behaviors on Baseline phase was 5.2, the mean on Treatment phase was 52.7 and the mean on Followed-Up phase was 32.5 intervals.

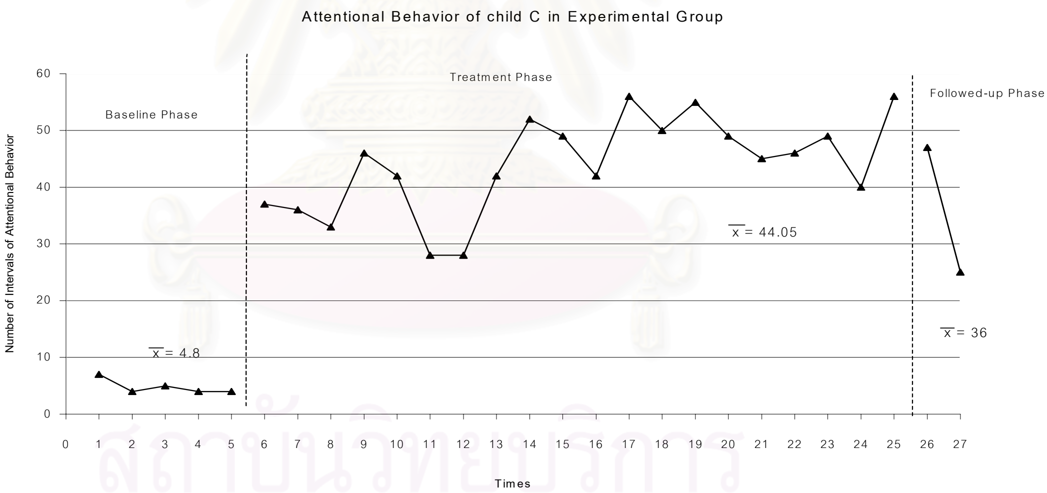
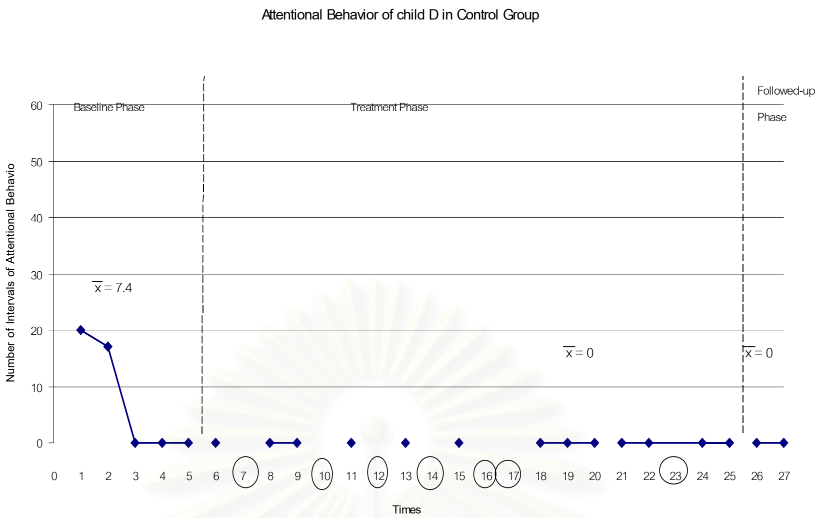
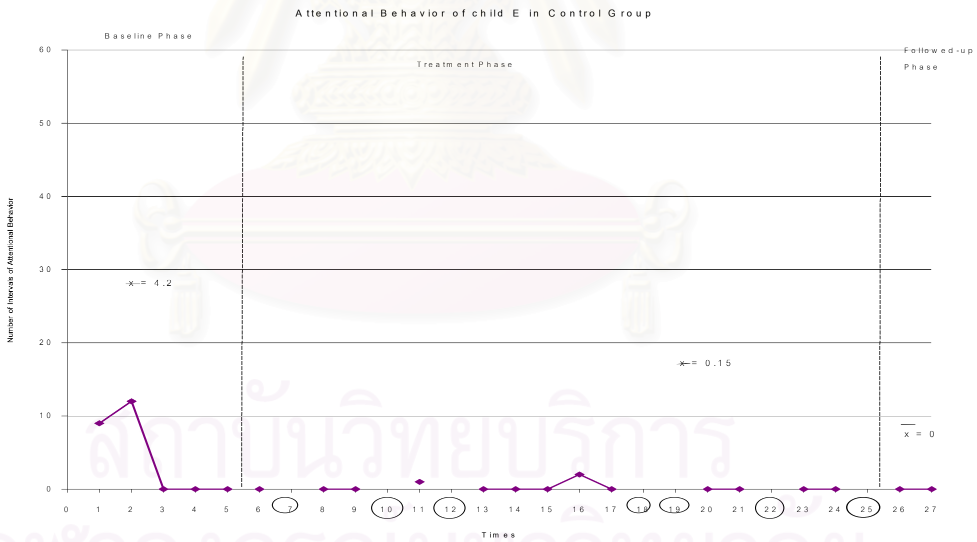


Fig.3 Attentional behaviors data of child C in experimental group. The mean of attentional behaviors on Baseline phase was 4.8, the mean on Treatment phase was 44.05 and the mean on Followed-Up phase was 36 intervals.



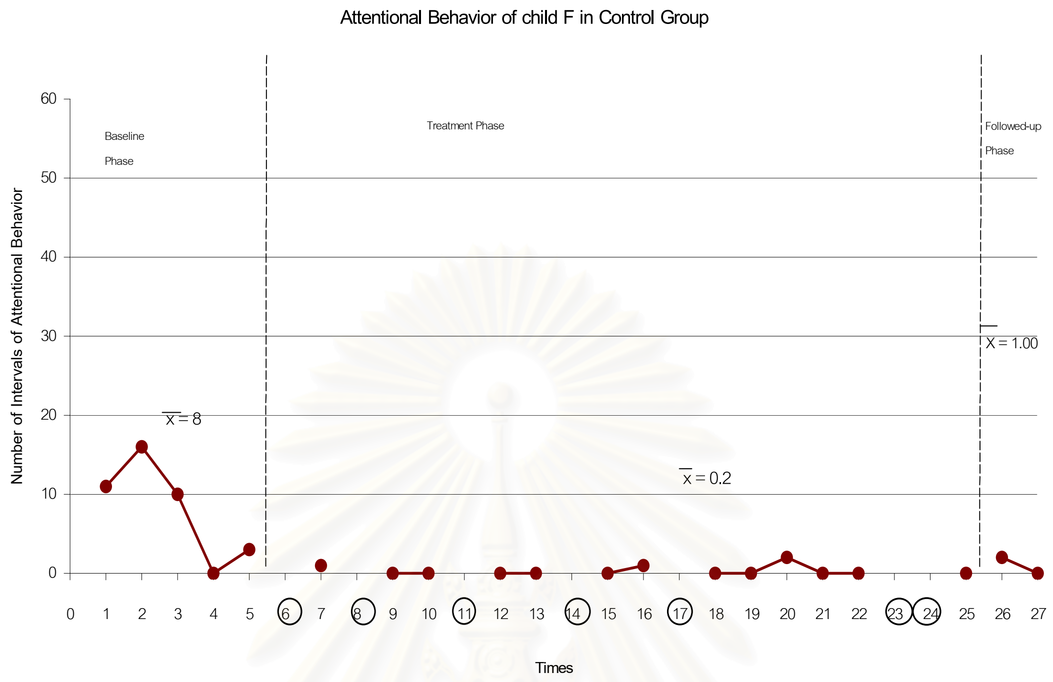
Note: ◯ *= missing data*

Fig.4 Attentional behaviors data of child D in control group. It showed the mean of attentional behaviors on Baseline phase was 7.4, the mean on Treatment phase was 0 and the mean on Followed-Up phase was 0 intervals.



Note: ◯ *= missing data*

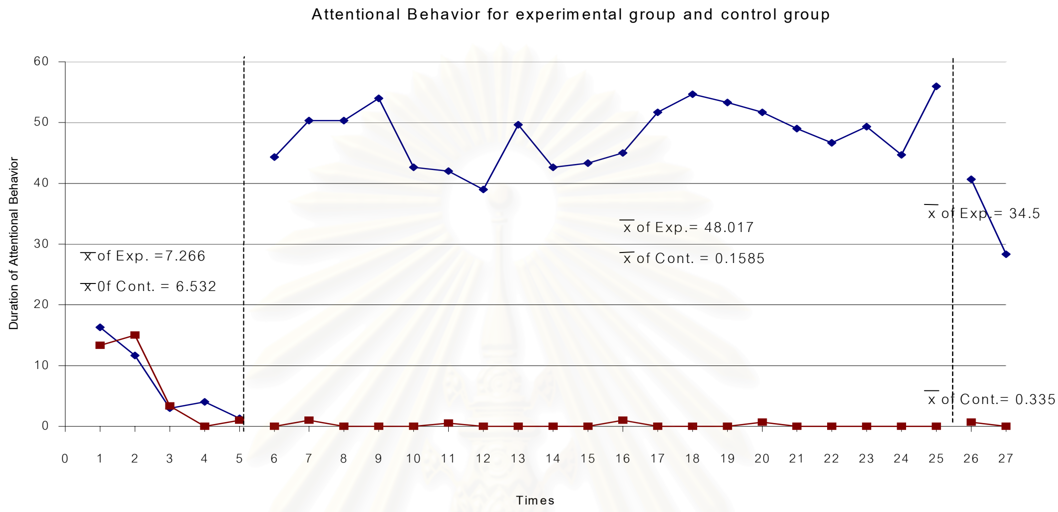
Fig.5 Attentional behaviors data of child E in control group. The mean of attentional behaviors on Baseline phase was 4.2, the mean on Treatment phase was 0.15 and the mean on Followed-Up phase was 0 intervals.



Note: ◯ = missing data

Fig.6 Attentional behaviors data of child F in control group. The mean of attentional behaviors on Baseline phase was 8, the mean on Treatment phase was 0.2 and the mean on Followed-Up Phase was 1 intervals.

Figure 7 Means of attentional behaviors for experimental and control groups on Baseline phase, Treatment phase, and Followed-up phase.



Note: ■ = *control group,* ◆ = *experimental group*

Fig.7 Attentional behaviors data for experimental and control groups. There is no difference between experimental ($\bar{x}$ = 7.266 intervals) and control groups ($\bar{x}$= 6.532 intervals) in baseline phase. There is highly difference between two groups in treatment phase. Participants in experimental group showed more attentional behaviors ($\bar{x}$ = 48.017 intervals) than the control group ($\bar{x}$ = 0.1585 interval).

Figure 8 Means of mathematics scores of participants in experimental group in the baseline, treatment, and followed-up phases.

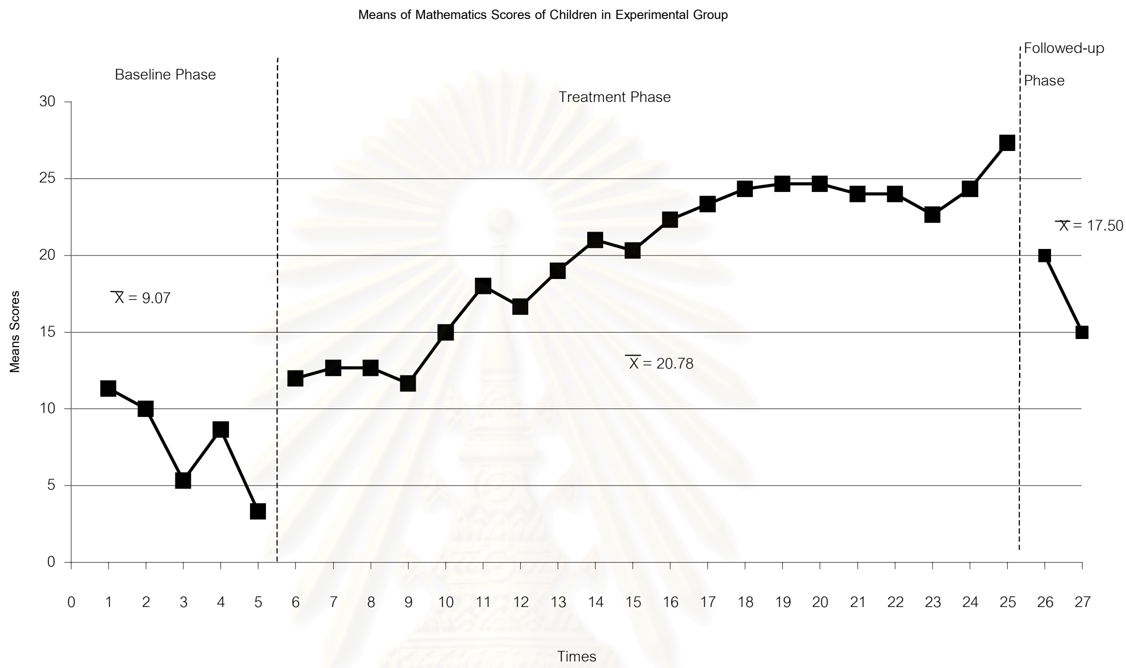


Fig.8 Means of mathematics sores of participants in experimental group. The data showed that on baseline phase the means of mathematics scores was 9.07 points, on treatment phase was 20.78 points, and on followed-up phase was 17.50 points.

Figure 9 showed means of beta/theta brainwaves ratios of normal children

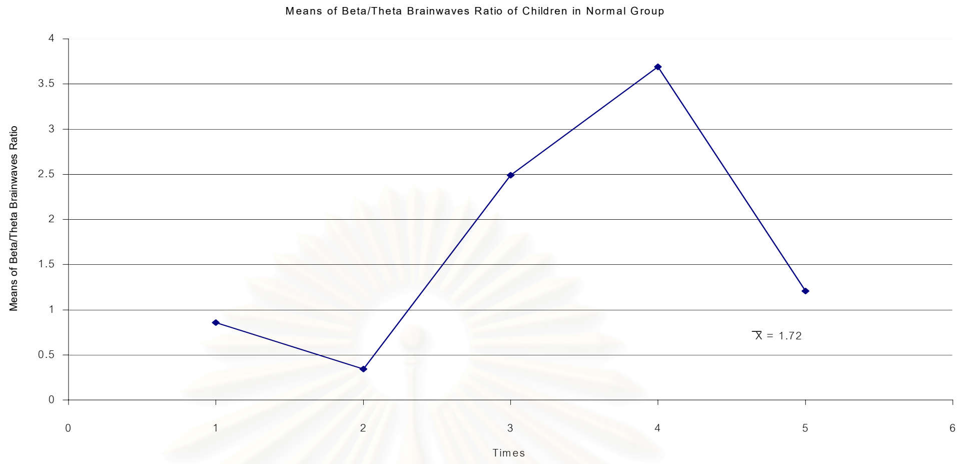


Fig.9 Means of beta/theta brainwaves ratios of normal children was 1.72 micro volts.

6. **Means and percentage table for** of beta/theta brainwaves ratios **during treatment phase of participants experimental group compared with the criterion of normal children.**

Table 6 Means and percentages of beta/theta brainwaves ratios of participants in experimental group compared with normal children.

Groups	Means	Percentages
Normal	1.72	100
Experimental	0.78	45.35

Table 6 showed that participants in experimental group could enhance the beta/theta brainwaves ratios o.78 microvolts, or reached 45.35 % of beta/theta brainwaves ratios of normal children.

7. **Beta/theta brainwaves ratios during the Baseline Phase.**

The independent-samples t-test was conducted to compare the beta/theta brainwave ratios for experimental and control groups during the Baseline phase. There was no significant differences in beta/theta brainwaves ratios between the experimental (M= .9980, SD= .5431), and control groups (M=.6420, SD=.1182;). (see Table 7)

Table 7 Results of the Independent-Sample t-test of beta/theta brainwaves ratios for experimental and control groups during the Baseline phase.

Group	n*	Mean	SD	df	t
Experimental	5	.998	.543	8	1.432
Control	5	.642	.118		

* *Note: n = numbers of sessions.*

8. **Beta/theta brainwaves ratios during the Treatment Phase.**

The independent-samples t-test was conducted to compare the beta/theta brainwaves ratios for experimental and control groups during the Treatment phases. There was no significant difference in beta/theta brainwaves ratios for experimental (M= .782, SD= .1018), and control groups (M=.642, SD=.1487). (see Table 8)

Table 8 Results of Independent-Sample t-test of brainwaves ratios for experimental and control groups during the Treatment phase.

Group	n*	Mean	SD	df	t
Experimental	20	.782	1.603	38	1.341
Control	20	.642	.148		

* *Note: n = numbers of sessions.*

Beta/theta brainwaves ratios of each participant in experimental group is showed in figure 10-12 and control group is shown in figure 13-15.

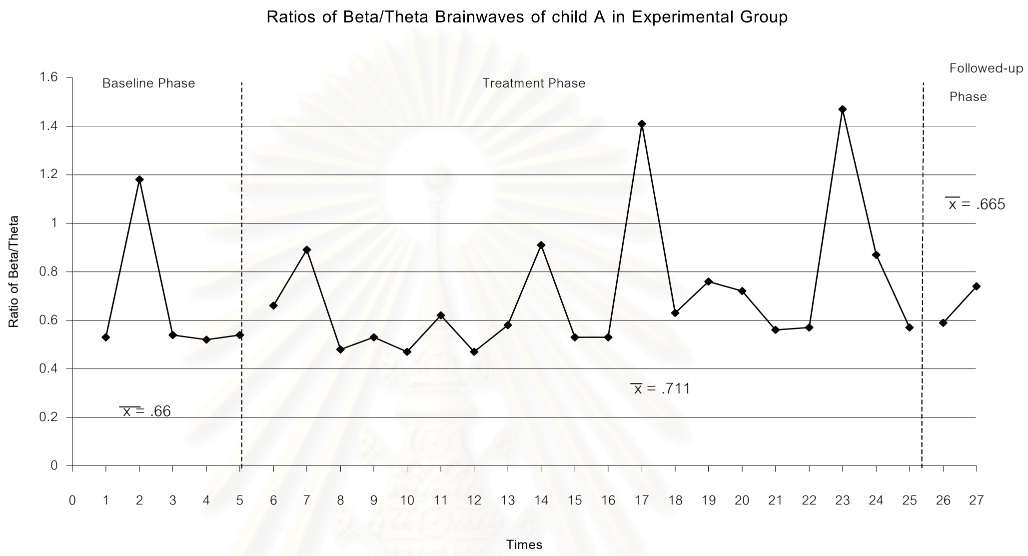


Fig.10 Beta/theta brainwaves ratios of child A in experimental group. The mean of baseline phase is 0.66 microvolts, the mean of treatment phase is 0.711 microvolts and mean of followed-up phase is 0.665 microvolts.

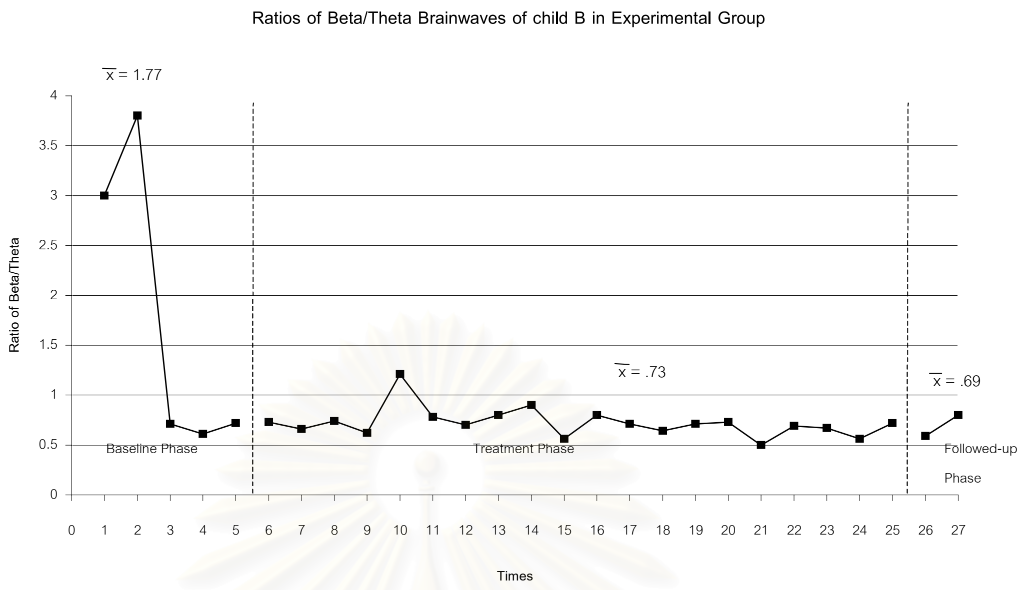


Fig.11 Beta/theta brainwaves ratios of child B in experimental group. The mean in baseline phase is 1.77 microvolts, the mean of treatment phase is 0.73 microvolts and the mean of followed-up phase is 0.69 microvolts.

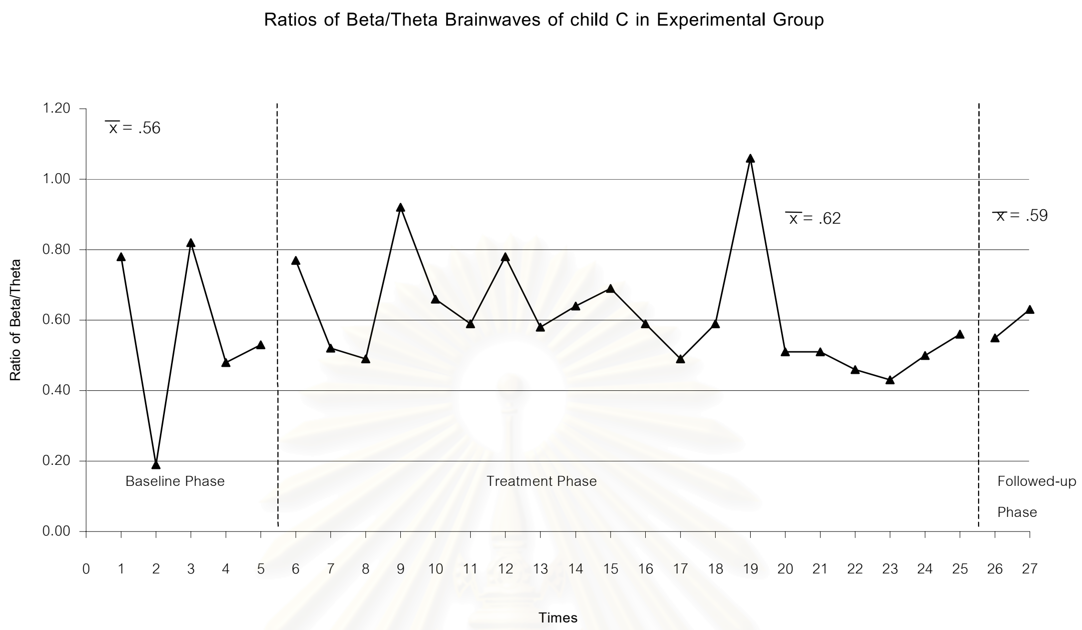
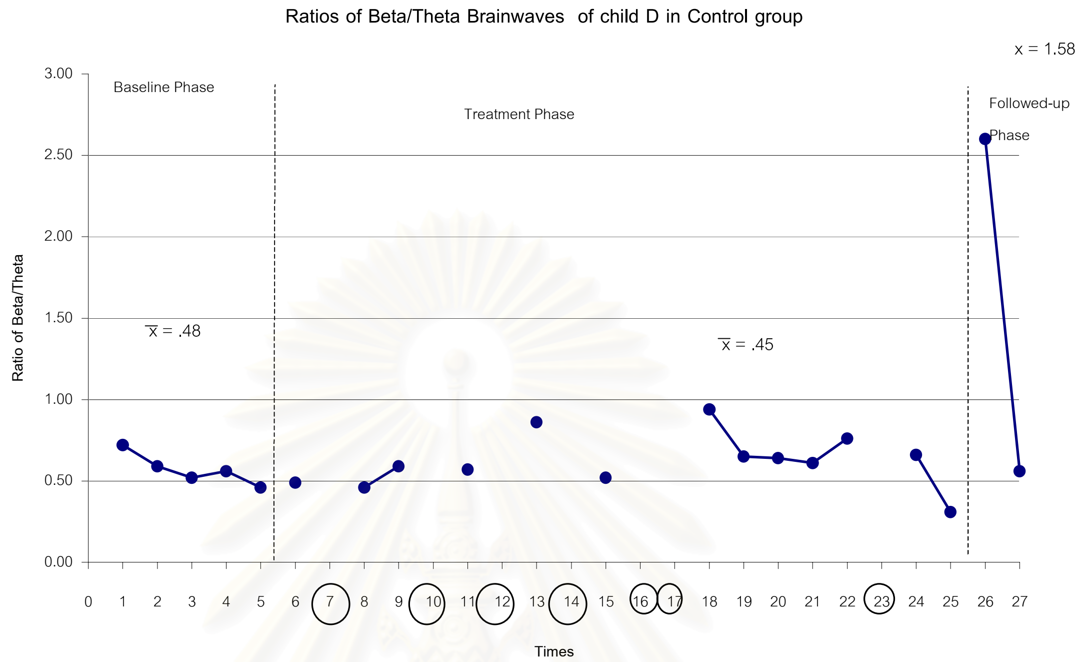
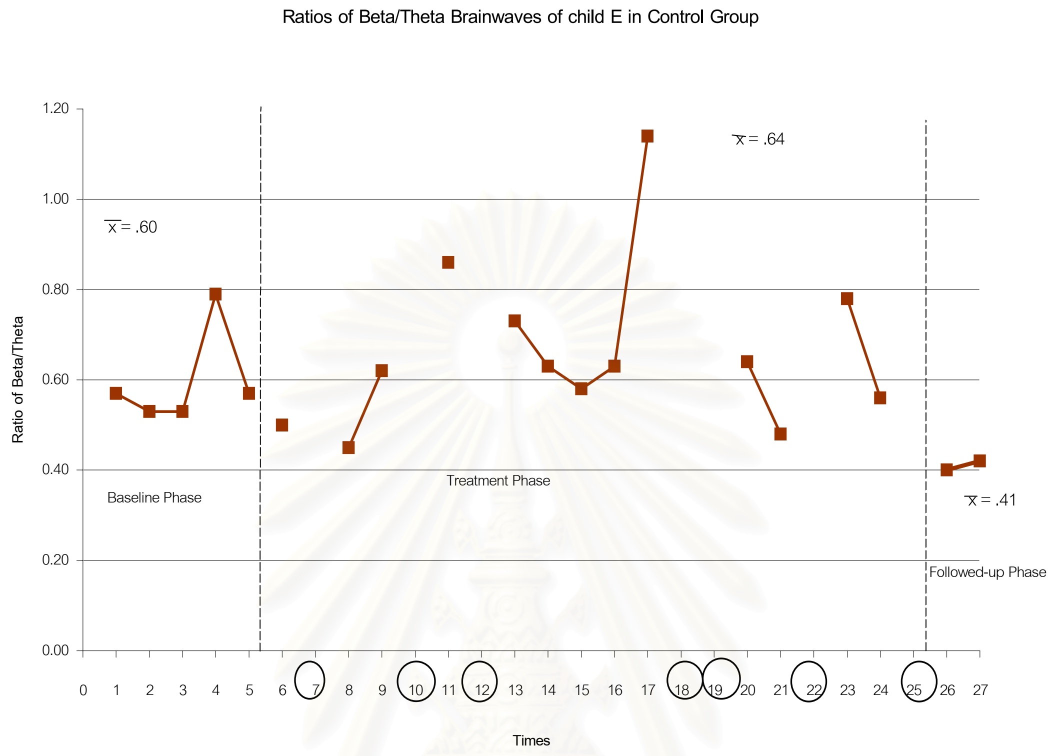


Fig.12 Beta/theta brainwaves ratios of child C in experimental group. The mean of baseline phase is 0.56 microvolts, the mean of treatment phase is 0.62 microvolts and the mean of followed-up phase is 0.59 microvolts.



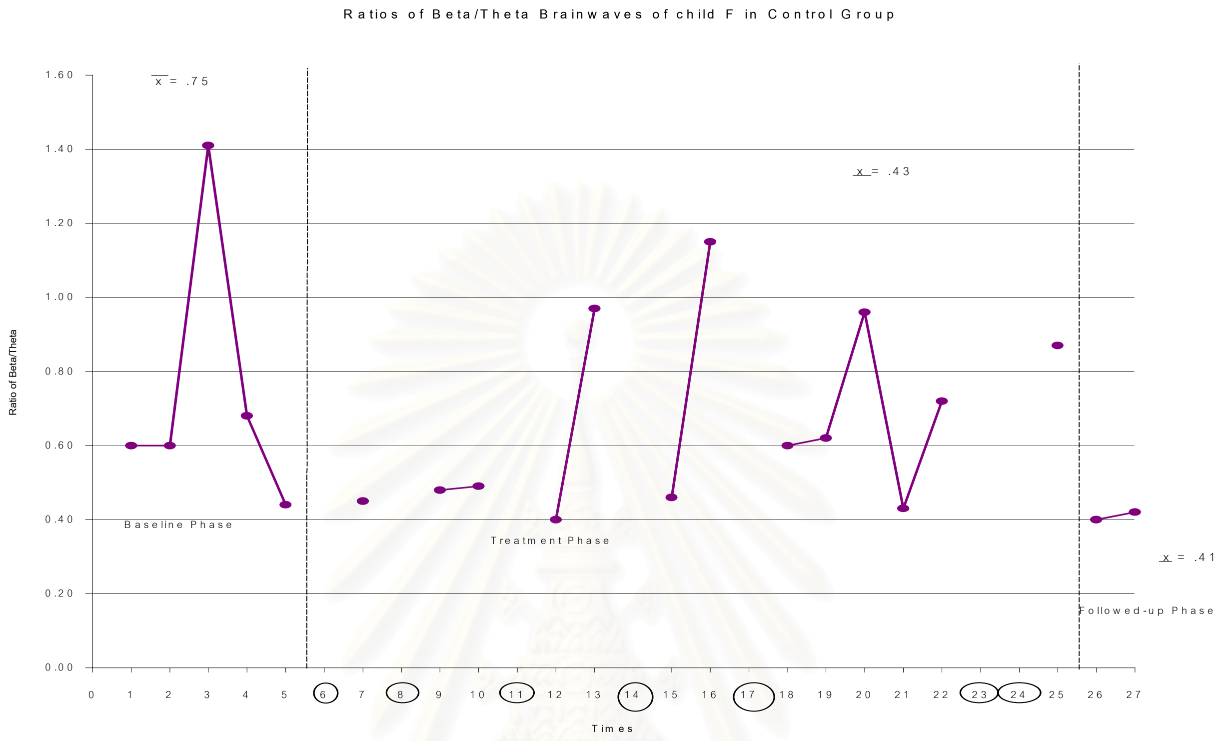
Note: ○ = *missing data*

Fig.13 Beta/theta brainwaves ratios of child D in Control group. The mean of baseline phase is 0.48 microvolts, the mean of treatmenht phase is 0.45 microvolts and the mean of followed-up phase is 1.58 microvolts.



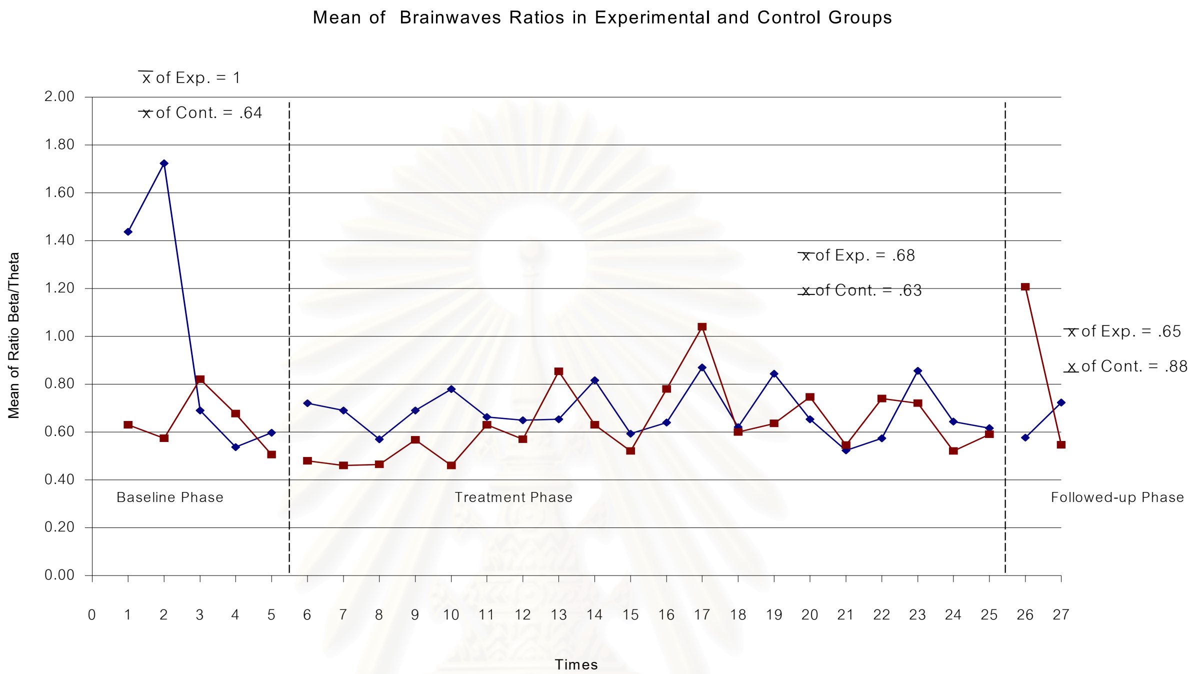
Note: ◯ = *missing data*

Fig.14 Beta/theta brainwaves ratios of child E in control group. The means of baseline phase is 0.60 microvolts, the means of treatment phase is 0.64 microvolts and the means of followed-up phase is 0.41 microvolts.



Note: ◯ = *missing data*

Fig.15 Beta/theta brainwaves ratios of child F in control group. The means of baseline phase is 0.75 microvolts, the means of treatment phase is 0.43 microvolts and the means of followed-up phase is 0.41 microvolts.



Note: ■ = *control group,* ◆ = *experimental group.*

Figure 16 The means of beta/theta brainwaves ratios for experimental and control groups on Baseline phase, Treatment phase, and Followed-up phase.

Chapter 4
Discussion

The purpose of this study was to examine the hypothesis that EEG-biofeedback and positive reinforcement could improve the attentional behaviors of 9.5 to 10.5 year-old children with ADHD. The researcher randomly assigned the participants (one girl and five boys) into experimental and control groups with 3 children in each group. All participants were diagnosed to be with ADHD (in inattentive type) by a physician. To confirm the diagnoses, parents and teachers of the participants were asked to complete the ADHD-Symptom Inventory (ADHD-SI), and parent and teacher versions of the ADHD/DSM-IV Scales. The result from ADHD-SI and ADHD/DSM-IV Scales confirmed that all of them were children with ADHD. An ABA Control Group research design was applied. The data was collected into two dimensions, attentional behaviors and beta/theta brainwaves. Child attentional behaviors in both experimental and control groups were compared across baseline and treatment phase by using t-test. Beta and theta waves of the experimental and control groups were analyzed by calculating the ratios of beta and theta brainwaves. Then, the researcher computed means and standard deviations of beta/theta brainwaves ratios and also compared those ratios across the baseline and treatment phases by using a t-test.

The results of attentional behaviors showed that there was no difference in attentional behavior for the experimental group (M=7.26, SD= 6.43), and the control group (M= 9.19, SD= 10.96) during the baseline phase. However, during the treatment phase, participants in the experimental group performed significantly more attentional behaviors than participants in the control group [$t(38)=44.009$, $p<.05$]. For the EEG data, there was no difference in the beta/theta brainwaves ratios between the experimental (M= 0.99, SD= 0.54) and control groups (M= 0.64, SD=0.11) during the baseline phase. During the treatment phase, there was also no difference in beta/theta brainwaves ratios between experimental group (M=0.68, SD=0.10) and control group (M=0.63, SD=0.15).

Statistically, we found no differences in the attentional behaviors between experimental and control groups during the Baseline phase (Table1). In the Treatment phase, however; we analyzed the means of attentional behaviors of the two groups and found a big difference between the attentional behaviors of participants in the two groups. (Table2). This suggests that the participants in the experimental group had significantly higher attentional behaviors than participants in the control group. This is because the researcher used EEG-biofeedback and positive reinforcement. These two techniques allowed them to improve their attentional behaviors. As we know that biofeedback is a kind of feedback that let the participants know the result of what they are doing which can help the participants know and improve their performance. Skinner noted that the consequences of behavior may provide "feedback" for the organism. When they do so, they may change the probability that the behavior which produced them will occur again (Skinner, 1953). Also, feedback generally is implicit in many types of reinforcers (Sarafino, 1996). The present study used the EEG-biofeedback technique for participants in experimental group. The participants received positive feedback (they could hear nothing from the EEG instrument) when they displayed appropriate attentional behaviors. The feedback functioned as a positive reinforcer to increase child attentional behaviors. This finding was similar to many studies that have found that brainwaves information could encourage children to reduce theta activity, increase beta activity, and improve their attentional behaviors (Anderson, et al., 2000; Kaiser, 1997; Linden, Habib, & Radojevic, 1996; Lubar, 1995; Lubar, Swartwood, Swartwood, & O,Donnell, 1995; Othmer, S., Kaiser, & Othmer, S.F., 1995; Othmer, et al., 1992). Further, it was similar to Warner and Barabasz (2000) who treated children with ADHD by using EEG-biofeedback, and Barabasz's alert hypnosis instantaneous neuronal activation procedure (INAP). They found fewer incidents of inattentive, impulsive, and hyperactive behaviors in their children following treatment. Children's rating of self-monitoring behaviors also improved.

Although biofeedback alone is sometimes sufficient to strengthen or maintain a behavior, combining feedback with other rewards, such as praise, usually works better (Sarafino, 1996). Therefore, this study used EEG-biofeedback combined with positive reinforcement. As Skinner (1953) noted that behavior was stamped in when followed by certain consequences and reinforcement. If a behavior was reinforced, it was strengthened: the probability increased that that type of behavior would be repeated in similar circumstances in the future (Cloninger, 2000). In this study positive reinforcement was the consequence after participants reached their goals. Positive reinforcement involved the addition of something (token economies, praise, candies, or games) to a situation after a response was made (Cloninger, 2000). As mention above, positive reinforcement increased the probability of a response—that is, it strengthened behavior. Moreover, participants received their reinforcers immediately after they performed attentional behaviors and reached their goals. Therefore, the attentional behaviors of participants in the experimental group was strengthened and improved more than the control group. This result was similar to many studies showing that positive reinforcement reduced unappropriate behavior and increased attentional behaviors. For example, Twardosz and Sajwaj (1972) found that prompting and positive reinforcement increased sitting in a hyperactive, retarded boy in a remedial preschool; decreased his hyperactive posturing; and increased his use of toys and proximity to other children. Iwata and Bailey (1974) examined the effects of reward and cost token procedures on the social and academic behavior of two groups of elementary special-education students by using a reversal design. They found that both procedures reduced rule violations and off-task behavior. One study found that token system in both contingencies and opportunities could consistently improve the attentional behaviors in children (Kazdin & Mascitelli, 1980). Moreover, positive reinforcement had both direct and indirect effects on on-task behavior. Especially, the direct procedure could maintain a large improvement of appropriate behavior (Boyd, Keilbaugh, & Axelrod, 1981). In Thailand, we also found the reduction of hyperactive behavior of children who had problems with hyperactivity in the reinforcement phase (Chinapandhu, 1974). Further, when we combined the positive reinforcement and shaping techniques on on-task behavior and task accuracy of children with ADHD, the children showed significantly better scores on on-task behaviors and task accuracy (Srichai, 2000).

However, the duration of attentional behaviors in the experimental group during the follow up phase decreased a little while the attentional behaviors in the control group remained unchanged (see figure7). This finding is a common phenomena of the reinforcement technique. Thus, we can sustain children's attentional behaviors by prolonging the treatment until their performance becomes habitual. Especially in this case, because children with ADHD need extended treatment to improve their chronic symptoms and behavior (Lubar, 1995; Tansey, 1993). In this study, however, the researcher had trained participants' parents about contingency management tactics-- such as positive reinforcement-- to improve their children's behavior. Although there are many ways to conduct parent training programs (Forehand & McMahon, 1981 cited in Barkley, 1997, Webster-Stratton, 1994), little is known about their benefits in treating children with ADHD (Barkley, 1997). We also have very few studies that examined the efficacy of this approach with children with ADHD (Anastopoulos & Shaffer, 2001). However, one study found that parent training decreased hostile parent behaviors and increased positive behaviors during simulated problematic parent-child interaction in clinic. Moreover, they found improvements in parent-child interaction in both the clinic and home settings that were maintained following the withdrawal of the training procedure and subsequent two-month posttreatment follow-up (Wolfe, St. Lawrence, Graves, Brehony, Bradlyn, & Kelly, 1982).

Although the observed attentional behaviors were improved, we found no difference of enhancing beta/theta brainwaves ratios in both of experimental and control groups during baseline and treatment phases (Table 7-8). However, we found that the trend of beta activity was increased. Therefore, it could not be concluded that attentional behaviors were not associated with the beta activity. The result of this finding may be due to the EEG instrument in the present study which had only two channels and therefore was not sensitive enough to detect the precise brainwaves activity. It could detect only average brainwaves activities. If we had a more sensitive EEG instrument to detect each brainwave separately, we may have found more differences of the enhanced beta/theta brainwaves ratios of each participant's brainwaves activity. However, this study found the trend of mathematics activities corrected scores that were higher than the baseline phase and seem to improve in treatment phase. It means the particiapnts in experimental group tried to focus on their tasks and tried to enhance the beta brainwaves (see Figure 9).

Further, during the Baseline phase, the present study found an irregular pattern of attentional behaviors in most experimental and control group participants. From the observing data, five participants had high attentional behaviors on the first day and fewer or no attentional behaviors after the first day. Especially the participants in the control group, they rarely had attentional behaviors on both treatment and follow-up phases. It may be the result of the laboratory setting. On the other hand, the children knew that their parents observed their behaviors on the first three days of the baseline phase. We could see that they had the same trend of attentional behaviors when they were in Baseline phase (see Figure 7).

However, this finding supported our hypothesis that EEG-Biofeedback and positive reinforcement could improve the attentional behaviors of experimental group children with ADHD while they did mathematics activities over 20 treatment sessions. EEG-biofeedback has been shown to be helpful with ADHD children (Othmer & Othmer, 1992) and it can be effective in reducing ADD or ADHD symptoms (Lubar, 1991; Lubar et al., 1995; Linden et al., 1996; Thompson & Thompson, 1998; Kaiser, Othmer, & Othmer, 2000; Warner et al., 1999). This was because the participants in experimental group were able to attend and concentrate on the tasks better (Linden et al., 1996). Moreover, EEG biofeedback, if performed in a private practice setting, should be done in conjunction with other modalities of treatment.

In conclusion, this study found that the application of EEG biofeedback and positive reinforcement proved to be a beneficial treatment component for children with ADHD.

Limitations of the Study

1. *The insensitivity of the instrument*. The EEG-biofeedback instrument used in this study was a two-channel type and could not provide precise brainwaves information for data analysis. The instrument could only provide an average brainwaves of the whole brain. Besides, the instrument was not sensitive in extracting brainwaves activity from the noise signals. Thus, the information received from this instrument was a mix-up signals of the brain activity and noise.

2. *The relatively short treatment duration*. In order to have a successful behavior intervention, a long duration of treatment phase is required. However, the availability of time that parents allowed their ADHD children to participate in the study was about 30 days. Thus, children had only 20 days to attend the treatment phase. The short duration of treatment that children received in the study was just about to start enhancing their beta/theta brainwaves ratio and improving their attentional behaviors. These effects, however, were not big enough to statistically demonstrate a significant difference from baseline phase. A longer duration of treatment phase of at least 40 days (linden et al., 1996; Lubar, 1995) was suggested.

Chapter 5
Conclusion and Suggestion

This study examined the hypothesis that EEG-Biofeedback and positive reinforcement could improve the attentional behaviors of 9.5 to 10.5 year-old children with ADHD. This study consisted of six children with ADHD (inattentive type). All participants were recruited from the Bangkok elementary schools. The six children with ADHD were randomly assigned into an experimental and control groups. An ABA control group research design was applied. The variables were as follows:

1. Independent Variables:
    - 1.1 Positive reinforcement for attentional behaviors.
    - 1.2 An audible signal (silence from the EEG-Biofeedback instrument) to the participant whenever he/she shows high theta brainwave activity.
2. Dependent Variables:
    - 2.1 Beta and theta brainwaves
    - 2.2 Child attentional behaviors

Purpose of the Study

The objective of this research was to examine how EEG biofeedback and positive reinforcement affects the attentional behavior of children with ADHD as they do mathematics activities.

Research Hypothesis

EEG biofeedback and positive reinforcement could improve the attentional behavior of children with ADHD while they perform mathematics activities.

Participants

One girl and five boys aged between 9.5 to 10.5 years old participated in the study. All participants were independently diagnosed as children with ADHD by a physician with the inattentive form of DSM-IV Attention-Deficit Hyperactivity Disorder. None of the participants were diagnosed with Learning Disability (LD). To confirm diagnoses, parents and teachers of the participants were asked to complete an ADHD-Symptom Inventory (ADHD-SI; Cox et al., 1998), and the parent and teacher versions of the Conners' ADHD/DSM-IV Scales (CADS; Conner, 2000). Results indicated that all the children had ADHD. All ADHD participants were free of psychostimulant medication over the preceding six months. After children with ADHD were identified, they and their parents were asked to meet the researcher to discuss and clarify project procedures, and to sign consent forms. Children with ADHD were randomly assigned into experimental and control groups comprising 3 children in each group.

Procedures

Preparation Phase

EEG laboratory was set up and an assessment of each participant reinforcer was done.

Experimental Phases

- ***Baseline Phase*** During mathematics activities, *beta wave and theta wave* were collected by EEG biofeedback. At the same time, child attentional behaviors were observed and recorded by two observers. Each baseline session took 30-minute duration and 5 sessions were done for each child. The child attentional behaviors was operationally defined into two dimensions 1) overt attentional behaviors while doing the task-at-hand (the mathematics tasks) and 2) beta and theta brainwaves activities.

- ***Treatment Phase*** A total of 20 treatment sessions were done for each ADHD participant. Each child received one 30-minute treatment session on weekday. The treatment sessions were divided into two sub-phases: sub-phase1 treatment by the researcher in the laboratory only, for the first 10 sessions and sub-phase 2 which contained two consecutive stages: (a) treatment in the laboratory, and in the child's home by the researcher, for 5 sessions; followed by (b) treatment by the researcher in the laboratory in the morning, and by the child's parents at home in the evening, for the last 5 sessions.

Experimental group participants got their reinforcers for performing attentional behaviors. Control and experimental groups participants were treated identically, except that the control group participants were not reinforced for any of their responses during treatment, and did not receive treatment at home.

- ***Follow-up Phase*** After treatment phase, each participant in the control and experimental groups received two additional EEG-biofeedback sessions and attentional behaviors were observed. Each follow-up session was done one week apart after the last treatment session. During the follow-up phase, no reinforcer was used.

Data Analysis

Since the data was collected into two dimensions, attentional behaviors and beta/theta brainwaves, mean and standard deviation were used to analyzed child attentional behaviors. Child attentional behaviors were also compared across baseline and treatment phase by using t-test.

The data from EEG-biofeedback, beta and theta brainwaves were analyzed by calculated the ratio of beta and theta brainwaves. After that the researcher computed means and standard deviations of beta/theta ratios and also compared those ratios across baseline and treatment phases by using t-test.

Results

1. Attentional Behavior

    1.1. Baseline Phase: There was no difference in attentional behaviors for experimental group ($M=7.26$, $SD= 6.43$), and control group ($M= 9.19$, $SD= 10.96$) during baseline phase.

    1.2 Treatment Phase: During treatment, ADHD children in the experimental group performed significantly more attentional behaviors than the children in control group [$t(38)=44.009$, $p<.05$].

2. EEG DATA (Beta-theta Brainwaves Ratios)

    2.1 Baseline Phase: There was no difference in beta/theta brainwaves ratios between experimental group ($M= 0.99$, $SD= 0.54$) and control group ($M= 0.64$, $SD=0.11$).

2.2 Treatment Phase: During treatment, There was no difference in beta/theta brainwaves ratios between experimental group (M=0.68, SD=0.10) and control group (M=0.63, SD=0.15).

Suggestions

1. The future study should have more sensitive EEG-biofeedback instrument to detect accuracy brainwaves activities.
2. The future study should have more time for the treatment phase to maintain child attentional behaviors in his/her long live.

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Appendices

Appendix A

Samples of Mathematics Activities

กิจกรรมคณิตศาสตร์ ชุดที่ 4

☐ **ให้แสดงวิธีทำ**

1. จังหวัด ก มีพลเมือง 526,000 คน จังหวัด ข มีพลเมืองมากกว่าจังหวัด ก 87,000 คน จังหวัด ค มีพลเมืองน้อยกว่าจังหวัด ข 69,000 คน จังหวัด ค มีพลเมืองเท่าไร

   ประโยคสัญลักษณ์ ____________________

   วิธีทำ ____________________

2. ปีนี้รัฐบาลแจกหนังสือคณิตศาสตร์รวม 1,680,000 เล่ม แยกเป็นหนังสือคณิตศาสตร์ ป.4 591,000 เล่ม หนังสือคณิตศาสตร์ ป.5 575,000 เล่ม ที่เหลือเป็นหนังสือคณิตศาสตร์ ป.6 รัฐบาลแจกหนังสือคณิตศาสตร์ ป.6 กี่เล่ม

   ประโยคสัญลักษณ์ ____________________

   วิธีทำ ____________________

3. เกษตรกรมีรายได้จากการเลี้ยงไก่ 344,580 บาท ซึ่งมากกว่ารายได้จากการขายข้าวอยู่ 84,900 บาท เกษตรกรมีรายได้จากการเลี้ยงไก่และขายข้าวเท่าไร

ประโยคสัญลักษณ์ ____________________

วิธีทำ ____________________

4. พ่อซื้อลูกปลาทั้งหมด 10,000 ตัว เลี้ยงในบ่อเลี้ยงปลาบ่อแรก 3,125 ตัว เลี้ยงในบ่อที่สอง 3,485 ตัว ที่เหลือเลี้ยงในบ่อที่สามพ่อเลี้ยงปลาในบ่อที่สามกี่ตัว

ประโยคสัญลักษณ์ ____________________

วิธีทำ ____________________

5. ปีนี้จิตราได้รับเงินเดือนรวม 114,240 บาท ได้รับเงินโบนัส 28,560 บาท ได้รับเงินจากเปอร์เซ็นต์การขายเครื่องสำอาง 152,000 บาท ปีนี้จิตรามีรายได้เท่าไร

ประโยคสัญลักษณ์ ______________________________

วิธีทำ ______________________________

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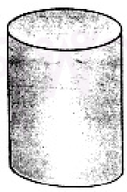
จงเลือกคำตอบที่ถูกต้อง

1. สิ่งใดมีส่วนที่เป็นระนาบ

   ก. ลูกฟุตบอล ข. ผลมะม่วง

   ค. หลอดไฟ ง. โต๊ะ

2. รูปทรงกระบอกตันประกอบด้วยส่วนที่เป็นระนาบกี่ส่วน



   ก. 1 ส่วน

   ข. 2 ส่วน

   ค. 3 ส่วน

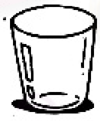
   ง. 4 ส่วน

3. สิ่งใดมีส่วนของเส้นตรงขนานกัน

   ก.

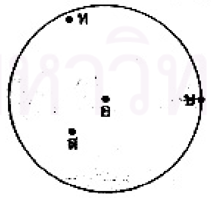
   ข.

   ค.



   ง.

4. จุดใดเป็นจุดศูนย์กลางของวงกลม

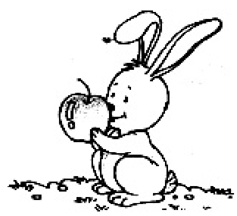


   ก. จุด ส

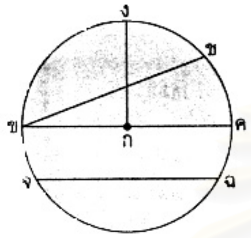
   ข. จุด ษ

   ค. จุด ห

   ง. จุด อ



5. จากรูป ข้อใดคือรัศมีของวงกลม



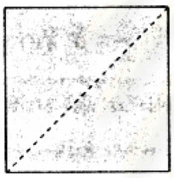
ก. $\overline{\text{กง}}$

ข. $\overline{\text{ขค}}$

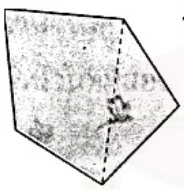
ค. $\overline{\text{ขช}}$

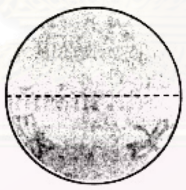
ง. $\overline{\text{จฉ}}$

6. เส้นประในรูปข้อใด**ไม่ใช่**แกนสมมาตร

ก. 

ข. 

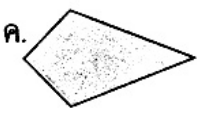
ค. 

ง. 

7. รูปใด**ไม่เป็น**รูปสมมาตร

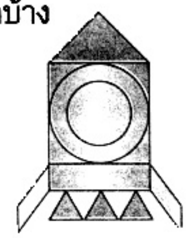
ก. 

ข. 

ค. 

ง. 

8. จากรูป ประกอบด้วยรูปเรขาคณิตชนิดใดบ้าง



ก. รูปวงรี รูปสามเหลี่ยม

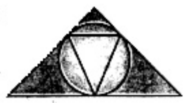
ข. รูปวงรี รูปวงกลม รูปสามเหลี่ยม

ค. รูปวงกลม รูปสามเหลี่ยม รูปสี่เหลี่ยม

ง. รูปวงรี รูปวงกลม รูปสามเหลี่ยม รูปสี่เหลี่ยม

9. รูปใดมีทั้งรูปวงกลม รูปสามเหลี่ยม และรูปสี่เหลี่ยม

ก. 

ข. 

ค. 

ง. 

10. สิ่งของในข้อใด**ไม่มี**ส่วนที่เป็นรูปสี่เหลี่ยม

ก. หนังสือ ข. ขวดน้ำอัดลม

ค. ปิ๊บ ง. กล่องไม้ขีด

☐ ให้เขียนคำอ่านของปีต่อไปนี้

1. พ.ศ. 2515 ______________________________
2. ค.ศ. 1972 ______________________________
3. พ.ศ. 2539 ______________________________
4. ค.ศ. 1998 ______________________________
5. พ.ศ. 2546 ______________________________

☐ เติมผลคูณลงในช่องว่างให้ถูกต้อง

1. $200 \times 315 =$	2. $305 \times 400 =$
3. $400 \times 227 =$	4. $600 \times 329 =$
5. $630 \times 500 =$	6. $478 \times 700 =$ ________
7. $900 \times 667 =$	8. $500 \times 398 =$
9. $800 \times 872 =$	10. $600 \times 951 =$

กิจกรรมคณิตศาสตร์ ชุดที่ 5

☐ เติมตัวเลขลงในช่องว่างให้ถูกต้อง

1. 352×168	2. 294×675
3. 416×537	4. 309×725
5. 811×299	6. 635×424
7. 549×792	8. 964×333

ให้เขียนเครื่องหมาย × ทับตัวอักษรหน้าคำตอบที่ถูกต้อง

1. 500,736 + 35,152 = □
   ก. 385,682 ข. 415,888
   ค. 435,888 ง. 535,888
2. 618,502 + 195,398 = □
   ก. 813,900 ข. 823,900
   ค. 826,900 ง. 843,800
3. 151,300 + 350 + 38,000 = □
   ก. 199,650 ข. 189,850
   ค. 189,650 ง. 159,615
4. จำนวนใดที่มากกว่า 409,150 อยู่ 15,000
   ก. 559,150 ข. 500,300
   ค. 424,150 ง. 415,850
5. การบวกในข้อใดมีการทดจากหลักหมื่นไปหลักแสน
   ก. 400,000 + 994,300
   ข. 3,143,500 + 464,300
   ค. 539,551 + 30,613
   ง. 5,315,932 + 141,935
6. 459,000 + 67,000 = □ มีค่าเท่ากับข้อใด
   ก. 426,000 + 10,000
   ข. 406,000 + 20,000
   ค. 400,000 + 120,000
   ง. 516,000 + 10,000
7. 1,840,500 - 440,200 = □
   ก. 1,400,300
   ข. 1,403,000
   ค. 1,430,000
   ง. 1,443,000
8. 1,143,055 - 985,865 = □
   ก. 154,190 ข. 157,190
   ค. 157,210 ง. 167,185
9. 3,715,000 - 853,000 = □ การหาผลลบในแนวตั้ง เลข 8 จะต้องวางให้ตรงกับตัวเลขใด
   ก. 1 ข. 3
   ค. 5 ง. 7
10. 549,350 - 154,784 = □ การหาผลลบจะต้องหาขั้นตอนใดก่อน
    ก. 84 - 50 ข. 50 - 84
    ค. 4 - 0 ง. 0 - 4
11. จำนวนใดที่น้อยกว่า 1,530,021 อยู่ 645,700
    ก. 884,321 ข. 784,321
    ค. 784,021 ง. 714,021

12. ฟาร์มแห่งหนึ่งเลี้ยงสัตว์ไว้ทั้งหมด 24,500 ตัว เป็นเป็ด 6,900 ตัว เป็นไก่ 12,000 ตัว ที่เหลือเป็นสุกร อยากทราบว่าเลี้ยงสุกรกี่ตัว
    ก. 3,400 ตัว ข. 4,600 ตัว
    ค. 5,600 ตัว ง. 6,500 ตัว

☐ **ให้เขียนเป็นประโยคสัญลักษณ์และหาคำตอบ**

1. น้อยมีธนบัตรฉบับละ 50 บาท อยู่ 65 ฉบับ น้อยมีเงินกี่บาท

   ประโยคสัญลักษณ์ ________________________________

   ตอบ ________________________________

2. ลุงปลูกมะม่วงไว้ 32 แถว แถวละ 54 ต้น ลุงปลูกมะม่วงทั้งหมดกี่ต้น

   ประโยคสัญลักษณ์ ________________________________

   ____

3. แม่ค้ามีเนื้อหมู 32 กิโลกรัม ราคากิโลกรัมละ 80 บาท ถ้าขายหมดจะได้เงินกี่บาท

   ประโยคสัญลักษณ์ ________________________________

   ตอบ ________________________________

4. โอ่งใบเล็กจุน้ำได้ 58 ลิตร โอ่งใบใหญ่จุน้ำได้มากกว่า 15 เท่าของโอ่งใบเล็ก โอ่งใบใหญ่จุน้ำได้กี่ลิตร

   ประโยคสัญลักษณ์ ________________________________

   ____

5. สำนักพิมพ์ส่งหนังสือไปขาย 365 กล่อง แต่ละกล่องจุหนังสือไว้ 48 เล่ม สำนักพิมพ์ส่งหนังสือไปขายกี่เล่ม

   ประโยคสัญลักษณ์ ________________________________

   ____

6. ร้านค้ารับกาแฟถุงมาขาย 255 ถุง แต่ละถุงหนัก 150 กรัม คิดเป็นน้ำหนักทั้งหมดกี่กรัม

   ประโยคสัญลักษณ์ ________________________________

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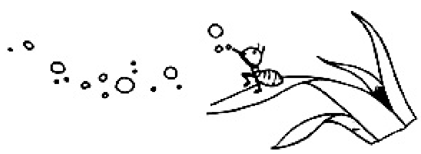
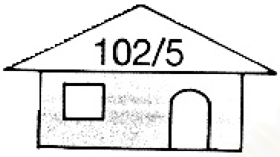


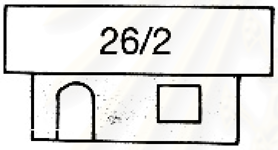


ควรจำ การอ่านเลขที่บ้านให้อ่านเรียงตัว หรืออ่านตามค่าประจำหลัก

102/5 อ่านว่า หนึ่งศูนย์สอง ทับ ห้า
หรือ หนึ่งร้อยสอง ทับ ห้า

4 **ให้เขียนคำอ่านของเลขที่บ้านต่อไปนี้**

1



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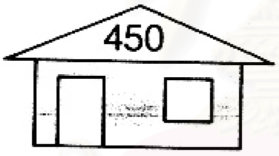
2.



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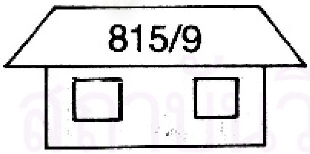
3.



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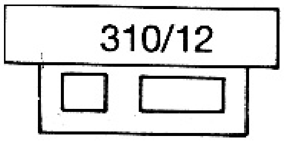
4.



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Appendix B
Questionnaire Assessment of ADHD

แบบทดสอบ Conners' ADHD/DSM-IV^{TM} Scales (CADS) **ฉบับแปล**

แบบประเมินสำหรับผู้ปกครอง

ชื่อเด็ก:______________________________________ เพศ: ชาย หญิง
วันเดือนปีเกิด:____/________/_______ อายุ:_______ ชั้นเรียน:___________
ชื่อผู้ปกครอง:__________________________ วันที่ประเมิน:___/________/_______

ข้อชี้แจง: ข้อกระทงด้านล่างนี้เป็นพฤติกรรมที่เป็นปัญหาของเด็ก กรุณาให้คะแนนสำหรับแต่ละพฤติกรรมเด็กของท่านที่เกิดขึ้นในเดือนที่ผ่านมา ในการตอบแต่ละข้อ กรุณาถามตนเองเสมอว่า "พฤติกรรมที่เป็นปัญหานี้เกิดขึ้นมากน้อยเพียงใด**ในเดือนที่ผ่านมา**" จากนั้นวงกลมตัวเลขที่คิดว่าเป็นคำตอบที่ถูกต้องที่สุด ถ้าพฤติกรรมนั้นไม่เกิดขึ้นเลยหรือนาน ๆ ครั้งจึงจะเกิด หรือเกิดขึ้นไม่บ่อยมากให้วงกลมเลข 0 หากพฤติกรรมนั้นตรงกับสิ่งที่เกิดขึ้นจริงหรือเกิดขึ้นเสมอหรือมีความถี่ของพฤติกรรมมาก ให้วงกลมเลข 3 และวงกลมเลข 1 หรือ 2 ได้ในกรณีที่มีพฤติกรรมอยู่ระหว่างการเกิดขึ้นมากและน้อย กรุณาตอบคำถามให้ครบทุกข้อ

หัวข้อ A กรุณาตอบข้อกระทงต่อไปนี้

	ไม่เกิดขึ้นเลย หรือเกิดขึ้น นาน ๆครั้ง	เกิดขึ้นเป็น บางครั้ง	เกิดขึ้นบ่อย	เกิดขึ้นมอ ๆ หรือเกิดขึ้น บ่อยมาก
1. หลีกเลี่ยง แสดงความไม่สมัครใจหรือมีความลำบากในการทำงานที่ต้องใช้สมาธิ (เช่น งานที่โรงเรียน หรือการบ้าน)............	0	1	2	3
2. ไม่สามารถติดตามการสอนได้ตลอด และทำงานที่โรงเรียนหรือทำงานที่ได้รับมอบหมายไม่เสร็จ (ไม่ได้เกิดเนื่องจากพฤติกรรมต่อต้านหรือไม่เข้าใจการเรียนการสอน)........	0	1	2	3
3. มีอาการมือหรือขาอยู่ไม่สุขหรือนั่งหยุกหยิก	0	1	2	3
4. ลุกออกจากที่นั่งในห้องเรียนหรือในสถาน-การณ์อื่นที่จำเป็นต้องอยู่กับที่................	0	1	2	3

หัวข้อ B กรุณาตอบข้อกระทงต่อไปนี้:

	ไม่เกิดขึ้นเลย หรือนาน ๆครั้ง	เกิดขึ้นเป็น บางครั้ง	เกิดขึ้นบ่อย	เกิดขึ้นเสมอ ๆ หรือบ่อยมาก
1. มีความลำบากในการรักษาสมาธิเมื่ออยู่ในห้องเรียน ………………………………………	0	1	2	3
2. สมาธิสั้น ถูกรบกวนได้ง่าย……………….	0	1	2	3
3. ทำตัวไม่มีระเบียบ ทิ้งของไว้รก เลอะเทอะทั้งที่บ้านและที่โรงเรียน……………………..	0	1	2	3
4. ว่อกแว่กง่ายหรือมีปัญหาเกี่ยวกับช่วงเวลาของความใส่ใจ………………………………	0	1	2	3
5. ทำท่าไม่สนใจเมื่อสอนให้ทำงานบางอย่าง	0	1	2	3
6. มีช่วงความใส่ใจสั้น………………………	0	1	2	3
7. มีความใส่ใจเฉพาะสิ่งที่เด็กสนใจมาก ๆ เท่านั้น …………………………………	0	1	2	3
8. มีอาการหงุดหงิด หัวเสียได้ง่าย ขณะที่ใช้ความพยายามในการทำงาน………………..	0	1	2	3

หัวข้อ C กรุณาตอบข้อกระทงต่อไปนี้:

1. เด็กทำท่า"พร้อมที่จะไป" หรือ "พร้อมที่จะเคลื่อนไหวอยู่เสมอ"……..…………………..	0	1	2	3
2. . มีความลำบากในการคงความใส่ใจในงานหรือกิจกรรมการเล่นได้นาน…..……………	0	1	2	3
3. เด็กทำท่าเหมือนไม่ตั้งใจฟังสิ่งที่คุณพูดกับเขา …………………………………………..	0	1	2	3
4. วิ่งหรือปีนป่ายอย่างไม่มีกาลเทศะ………..	0	1	2	3
5. มีความลำบากในการจัดระบบการทำงานหรือกิจกรรม …………………………………..	0	1	2	3
6. พูดมากเกินควร……………………………	0	1	2	3
7. ไม่สามารถให้ความใส่ใจต่อรายละเอียดต่าง ๆ ของงานหรือขาดความระมัดระวังจนทำให้เกิดความผิดพลาดในงานที่ได้รับมอบหมายหรือกิจกรรมอื่น ๆ…………………	0	1	2	3

	ไม่เกิดขึ้นเลย หรือนาน ๆครั้ง	เกิดขึ้นเป็น บางครั้ง	เกิดขึ้นบ่อย	เกิดขึ้นเสมอ ๆ หรือบ่อยมาก
8. มีความลำบากในการรอคอยให้ถึงลำดับของตน......	0	1	2	3
9. แทรกแซงหรือก่อกวนผู้อื่น (เช่น เข้าไปรบกวนการสนทนา หรือการเล่นเกม).............	0	1	2	3
10. ลืมสิ่งที่เป็นกิจวัตรประจำวัน................	0	1	2	3
11. ไม่สามารถเล่นหรือพักผ่อนอย่างเงียบ ๆ ได้	0	1	2	3
12. ทำของหาย ไม่ว่าจะเป็นสิ่งที่จำเป็นในการทำงานหรือกิจกรรมหาย (เช่น งานที่ได้รับมอบหมายจากทางโรงเรียน ดินสอ สมุด อุปกรณ์ หรือของเล่น).........................	0	1	2	3
13. ถูกรบกวน (เบนความสนใจ) โดยสิ่งเร้าภายนอกได้ง่าย	0	1	2	3
14. โพล่งตอบก่อนที่จะฟังคำถามจบ...........	0	1	2	3

แบบทดสอบ Conners' ADHD/DSM-IV™ Scales (CADS) **ฉบับแปล**

แบบประเมินสำหรับครู

ชื่อนักเรียน:________________________ เพศ: ชาย หญิง
วันเดือนปีเกิด:____/________/_______ อายุ:________ ชั้นเรียน:___________
ชื่ออาจารย์ผู้สอน:________________________ วันที่ประเมิน:____/________/_______

ข้อชี้แจง: ข้อกระทงด้านล่างนี้เป็นพฤติกรรมที่เป็นปัญหาของเด็กในโรงเรียน กรุณาให้คะแนนที่เป็นพฤติกรรมที่เกิดขึ้นในเดือนที่ผ่านมา ในการตอบแต่ละข้อ กรุณาถามตนเองเสมอว่า "พฤติกรรมที่เป็นปัญหานี้เกิดขึ้นมากน้อยเพียงใดเมื่อ**เดือนที่ผ่านมา**" จากนั้นวงกลมตัวเลขที่คิดว่าเป็นคำตอบที่ถูกต้องที่สุด ถ้าพฤติกรรมนั้นไม่เกิดขึ้นเลยหรือนาน ๆ ครั้งจึงจะเกิด หรือเกิดขึ้นน้อยมากให้ตอบ 0 หากพฤติกรรมนั้นเกิดขึ้นเสมอหรือมีความถี่ของพฤติกรรมมาก ให้วงกลมเลข 3 คุณสามารถวงกลมเลข 1 หรือ 2 ได้ในกรณีที่มีพฤติกรรมอยู่ระหว่างการเกิดขึ้นมากและน้อย กรุณาตอบคำถามให้ครบทุกข้อ

หัวข้อ A กรุณาตอบข้อกระทงต่อไปนี้

	ไม่เกิดขึ้นเลยหรือนาน ๆครั้ง	เกิดขึ้นเป็นบางครั้ง	เกิดขึ้นบ่อย	เกิดขึ้นเสมอ ๆ หรือบ่อยมาก
1. แทรกแซงหรือก่อกวนผู้อื่น (เช่น เข้าไปรบกวนการเล่นเกม หรือการสนทนา)…………	0	1	2	3
2. ไม่สามารถติดตามการสอนได้ตลอด และทำการบ้านไม่เสร็จ (ไม่ได้เกิดเนื่องจากมีพฤติกรรมต่อต้านหรือไม่เข้าใจการเรียนการสอน)………………………………………	0	1	2	3
3. มีอาการมือหรือขาอยู่ไม่สุขหรือนั่งหยุกหยิก ………………………………………	0	1	2	3

หัวข้อ B กรุณาตอบข้อกระทงต่อไปนี้:

	ไม่เกิดขึ้นเลยหรือนาน ๆครั้ง	เกิดขึ้นเป็นบางครั้ง	เกิดขึ้นบ่อย	เกิดขึ้นเสมอ ๆ หรือบ่อยมาก
1. ตื่นเต้นง่ายหรือหุนหันพลันแล่น…………..	0	1	2	3
2. สมาธิสั้น ถูกรบกวนได้ง่าย………………..	0	1	2	3
3. รบกวนเด็กคนอื่น ๆ………………………	0	1	2	3
4. อยู่นิ่ง ๆ ไม่ได้…………………………	0	1	2	3
5. มีช่วงความใส่ใจสั้น………………………	0	1	2	3
6. จะมีความใส่ใจต่อสิ่งที่ตนเองสนใจเท่านั้น	0	1	2	3
7. วอกแวกหรือมีปัญหาเกี่ยวกับช่วงเวลาของความใส่ใจ	0	1	2	3
8.ไม่อยู่เฉย มักมีพฤติกรรมพร้อมที่จะไป	0	1	2	3
9. มักทำงานไม่เสร็จ…………………………	0	1	2	3

หัวข้อ C กรุณาตอบข้อกระทงต่อไปนี้: ρ ตอบ ρ ไม่ตอบ

1. ลืมสิ่งที่ตนเรียนไปแล้ว…………………….	0	1	2	3
2. ไม่สามารถให้ความใส่ใจต่อรายละเอียดต่าง ๆ ของงาน หรือขาดความระมัดระวังจนทำให้เกิดความผิดพลาดในงานที่ได้รับมอบหมายหรือกิจกรรมอื่น ๆ	0	1	2	3
3. ทำท่า “พร้อมที่จะไป” หรือ “พร้อมที่จะเคลื่อนไหวอยู่เสมอ”…………………..	0	1	2	3
4. หลีกเลี่ยง แสดงความไม่สมัครใจ หรือมีความลำบากในการทำงานที่ต้องใช้สมาธิ..	0	1	2	3
5. ไม่สามารถเล่นหรือพักผ่อนอย่างเงียบๆ ได้	0	1	2	3
6. ทำท่าเหมือนไม่ตั้งใจฟังสิ่งที่คุณพูดกับเขา	0	1	2	3
7. ลุกออกจากที่นั่งในห้องเรียนหรือในสถาน-การณ์อื่นที่จำเป็นต้องนั่งอยู่กับที่……………	0	1	2	3

	ไม่เกิดขึ้นเลย หรือนาน ๆครั้ง	เกิดขึ้นเป็น บางครั้ง	เกิดขึ้นบ่อย	เกิดขึ้นเสมอ ๆ หรือบ่อยมาก
8. มีความลำบากในการจัดการระบบการทำงานหรือ กิจกรรม……………………..	0	1	2	3
9. มีความลำบากในการรอคอยให้ถึงลำดับของตน	0	1	2	3
10. พูดมากเกินควร………………………….	0	1	2	3
11. วิ่งหรือปีนป่ายอย่างไม่มีกาลเทศะ…..	0	1	2	3
12. รีบตอบก่อนที่จะฟังคำถามจบ………..	0	1	2	3
13. ทำของหาย โดยเฉพาะสิ่งที่จำเป็นในการทำงานหรือ กิจกรรม (เช่น งานที่ได้รับมอบหมายจากทางโรงเรียน ดินสอ สมุด อุปกรณ์ หรือของเล่น)……………………	0	1	2	3
14. ถูกรบกวน (เบนความสนใจ) โดยสิ่งเร้าภายนอกได้ง่าย ………………………………	0	1	2	3
15. มีความลำบากในการคงความใส่ใจในงานหรือกิจกรรม การเล่นได้นาน……………….	0	1	2	3

ADHD Symptoms Inventory (ADHD-SI) (Teacher and Parent Versions) **ฉบับแปล**

ข้อชี้แจง: โปรดวงกลมหมายเลขที่ท่านคิดว่า สามารถอธิบายพฤติกรรมเด็กของท่านได้ดีที่สุดในช่วงระยะเวลา 6 เดือนที่ผ่านมา

0 = ไม่มีพฤติกรรมนี้เกิดขึ้น

1 = มีพฤติกรรมนี้เกิดขึ้นเป็นบางครั้ง หรือเกิดขึ้นในระยะเวลาไม่ถึง 6 เดือน

2 = มีพฤติกรรมนี้เกิดขึ้นเสมอ ๆ

1. เด็กไม่สามารถให้ความใส่ใจต่อรายละเอียดต่าง ๆ ของงาน หรือขาดความระมัดระวังจนทำให้เกิดความผิดพลาดในงานที่ได้รับมอบหมาย	0	1	2
2. เป็นการยากที่จะให้เด็กคงความใส่ใจในการทำงานหรือเล่นได้นาน	0	1	2
3. เด็กทำเหมือนไม่ตั้งใจฟัง เมื่อคุณพูดกับเขา	0	1	2
4. เด็กมักทำได้ไม่ครบถ้วนตามที่สั่งและทำงานต่าง ๆ ที่ได้รับมอบหมายไม่เสร็จ ไม่ว่าจะเป็นงานของโรงเรียนหรืองานที่บ้าน	0	1	2
5. เด็กมีความลำบากในการจัดลำดับการทำงานหรือกิจกรรมต่าง ๆ	0	1	2
6. เด็กมักแสดงความไม่ชอบหรือหลีกเลี่ยงที่จะทำงานที่ต้องใช้สมาธิ เช่น การเรียนในห้องเรียนหรือการทำการบ้าน	0	1	2
7. เด็กมักทำสิ่งของที่จำเป็นในการทำงานหรือกิจกรรมหาย (เช่น ของเล่น งานที่ต้องทำส่งครู ดินสอ สมุด หรืออุปกรณ์การเรียน)	0	1	2
8. เด็กมักถูกเบนความสนใจโดยสิ่งเร้าจากภายนอกได้ง่าย	0	1	2
9. เด็กมักหลงลืมสิ่งที่เป็นกิจวัตรประจำวันของตน	0	1	2
10. เด็กมักมีอาการมือหรือขาอยู่ไม่สุข หรือนั่งไม่ติดอยู่กับที่	0	1	2
11. เด็กมักลุกจากเก้าอี้ในชั้นเรียน หรือในสภาพการณ์อื่น ๆ ที่จำเป็นต้องนั่งอยู่กับที่	0	1	2
12. เด็กมักวิ่งหรือปีนป่ายอยู่ตลอดเวลา ในสภาพการณ์เวลาที่ไม่เหมาะสม	0	1	2
13. เด็กไม่สามารถเล่น หรือพักผ่อนอย่างเงียบ ๆ ได้	0	1	2
14. เด็กทำท่าเหมือน “พร้อมที่จะไป” หรือ “พร้อมที่จะเคลื่อนไหว”	0	1	2
15. เด็กมักพูดมากเกินควร	0	1	2
16. เด็กมักโพล่งตอบก่อนที่จะฟังคำถามจบ	0	1	2
17. เด็กมักทนรอให้ถึงลำดับของตนไม่ไหว	0	1	2
18. เด็กมักก่อกวนหรือแทรกแซง (เช่น พูดแทรกการสนทนาของบุคคลอื่น หรือแย่งของคนอื่นเล่น)	0	1	2

*Cox, D.J. (1998).

Appendix C
Instructions

Instruction for Baseline Phase

ในตลอดการทดลอง คุณจะต้องนั่งเก้าอี้ในท่าที่คุณคิดว่าสบายและสะดวกในการทำกิจกรรมมากที่สุด ผู้วิจัยจะติดเครื่องมือวัดคลื่นสมองบนศีรษะของคุณ ขอให้คุณพยายามนั่งนิ่ง ๆ ไม่ควรเคลื่อนไหวหากไม่จำเป็น เนื่องจากการเคลื่อนไหวจะไปกระทบกระเทือนต่อการอ่านคลื่นสมองของเครื่องมือได้

ระยะเวลาในการทดลองและทำกิจกรรมคณิตศาสตร์จะใช้เวลา 30 นาที ผู้วิจัยจะมีกิจกรรมคณิตศาสตร์ทั้งหมด 5 ชุด คุณสามารถเลือกทำกิจกรรมคณิตศาสตร์ชุดใดก็ได้เพียง 1 ชุด และคุณจะเริ่มทำกิจกรรมก็ต่อเมื่อผู้วิจัยพูดคำว่า “เริ่ม”

ย้ำอีกครั้ง กรุณานั่นนิ่งๆ ไม่ควรส่ายหน้าหรือเคลื่อนไหวศีรษะ และพยายามนั่งในท่าที่สะดวกสบายต่อการทำกิจกรรมให้มากที่สุด

Instruction for Treatment Phase

วันนี้จะเป็นการเริ่มต้นฝึกพลังสมอง ในการฝึกเวลา 30 นาที โดยผู้วิจัยจะติดเครื่องวัดคลื่นสมองไว้บนศีรษะของคุณ ขอให้คุณนั่งเก้าอี้ในท่าที่คุณคิดว่าสบายและสะดวกในการทำกิจกรรมมากคณิตศาสตร์ที่สุดเช่นเดียวกับตอนวัดคลื่นสมอง 5 วันแรก และพยายามเคลื่อนไหวให้น้อยที่สุดเพื่อไม่ให้กระทบกระเทือนต่อการอ่านค่าคลื่นสมองของเครื่องมือ

ผู้วิจัยจะมีกิจกรรมคณิตศาสตร์ทั้งหมด 5 ชุด คุณสามารถเลือกทำกิจกรรมคณิตศาสตร์ชุดใดก็ได้เพียง 1 ชุด และคุณจะเริ่มทำกิจกรรมก็ต่อเมื่อผู้วิจัยพูดคำว่า “เริ่ม”

ในขณะที่คุณนั่งทำกิจกรรม หากมีเสียงดังขึ้นจากลำโพงแสดงว่าคลื่นสมอง/พลังสมองของคุณอ่อนกำลังลง ขอให้คุณพยายามตั้งใจทำกิจกรรมให้มากยิ่งขึ้น เมื่อเสียงนั้นเงียบลงแสดงว่าคลื่นสมอง/พลังสมองแข็งแกร่งขึ้นแล้ว ถ้าคุณมีพฤติกรรมตั้งใจทำกิจกรรมคณิตศาสตร์และไม่มีเสียงดังเกิดขึ้นตามเวลาที่กำหนด คุณจะได้รับสติกเกอร์สะสมคะแนนจากผู้วิจัย 1 ดวง และเมื่อคุณสะสมสติกเกอร์ได้ครบ 30 ดวง คุณสามารถนำสติกเกอร์ 30 ดวงนั้นมาแลกการ์ดซัมมอนเนอร์ได้ 1 ใบ และถ้าคุณสามารถฝึกคลื่นสมอง/พลังสมองได้จนสามารถสะสมการ์ดได้ 10 ใบ คุณจะได้รับรางวัลที่ทำการตกลงกับผู้วิจัยไว้แล้ว

ขอย้ำอีกครั้ง พยายามตั้งใจทำกิจกรรมคณิตศาสตร์ให้ดีที่สุด และขอให้นั่งนิ่ง ๆ ไม่ควรเคลื่อนไหวหากไม่จำเป็น ขอบคุณสำหรับความร่วมมือ

Appendix D

Tables and Figures

RELIABILITY ANALYSIS - SCALE (ALPHA)

Conners' ADHD DSM-IV Scales (CADS; Conner' 2000; Parent Version)

N of Cases = 30.0

Item Means	Mean	Minimum	Maximum	Range	Max/Min	Variance
	1.9077	1.1333	2.4000	1.2667	2.1176	.0881

RELIABILITY ANALYSIS - SCALE (ALPHA)

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
VAR00001	47.6667	120.7126	.2468	.	.8615
VAR00002	47.8333	122.7644	.1276	.	.8656
VAR00003	47.4000	112.6621	.6051	.	.8502
VAR00004	47.7667	112.9437	.6245	.	.8499
VAR00005	47.6667	118.3678	.4374	.	.8561
VAR00006	47.3333	118.9885	.4288	.	.8565
VAR00007	47.2667	116.5471	.5045	.	.8541
VAR00008	47.4000	117.9724	.6118	.	.8534
VAR00009	47.5667	118.6678	.4322	.	.8563
VAR00010	47.4667	118.6713	.4930	.	.8553
VAR00011	47.2000	120.7862	.2799	.	.8602
VAR00012	47.9333	117.3747	.3459	.	.8591
VAR00013	47.7000	112.7000	.6585	.	.8490
VAR00014	48.1000	114.7828	.6260	.	.8508
VAR00015	47.7000	124.8379	.0479	.	.8666
VAR00016	48.0000	112.8966	.5460	.	.8520
VAR00017	47.4000	124.3172	.1145	.	.8635
VAR00018	47.7333	115.7885	.3968	.	.8575
VAR00019	47.6000	121.4207	.2228	.	.8620
VAR00020	47.9667	113.2747	.5123	.	.8532

Scale Scale Corrected

	Mean if Item Deleted	Variance if Item Deleted	Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
VAR00021	47.9333	111.9954	.5935	.	.8503
VAR00022	47.7333	116.5471	.4086	.	.8568
VAR00023	48.4667	117.3609	.3699	.	.8581
VAR00024	47.6333	118.0333	.2913	.	.8614
VAR00025	47.4333	121.1506	.3801	.	.8581
VAR00026	48.1000	115.0586	.4442	.	.8557

Reliability Coefficients 26 items

Alpha = .8615 Standardized item alpha = .8653

Conners' ADHD DSM-IV Scales (CADS; conners, 2000; Teacher Version)

N of Cases = 30.0

	Mean	Minimum	Maximum	Range	Max/Min	Variance
Item Means	1.8210	1.2000	2.4667	1.2667	2.0556	.1513

RELIABILITY ANALYSIS - SCALE (ALPHA)

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
VAR00001	47.9333	95.2368	.5083	.	.8134
VAR00002	47.2667	106.4092	-.1456	.	.8383
VAR00003	47.3000	90.0793	.6500	.	.8053
VAR00004	47.4000	95.5586	.4882	.	.8142
VAR00005	46.7667	93.3575	.5977	.	.8096
VAR00006	47.6333	92.5851	.5850	.	.8093
VAR00007	47.7333	94.2713	.5144	.	.8126
VAR00008	46.7000	97.4586	.4195	.	.8172
VAR00009	46.8667	99.5678	.2528	.	.8229
VAR00010	46.7000	96.5621	.6094	.	.8129
VAR00011	47.6000	98.5931	.3221	.	.8204
VAR00012	47.1000	107.4034	-.2258	.	.8373
VAR00013	47.5000	110.3276	-.3694	.	.8442
VAR00014	47.2667	106.0644	-.1343	.	.8357
VAR00015	47.5667	93.3575	.5697	.	.8104
VAR00016	46.9333	100.1333	.2425	.	.8231
VAR00017	47.8333	99.3161	.2351	.	.8239
VAR00018	47.3000	98.4241	.3318	.	.8201
VAR00019	47.7000	98.7000	.2786	.	.8222
VAR00020	47.0667	99.2368	.2150	.	.8252
VAR00021	47.3333	91.7471	.6234	.	.8075
VAR00022	47.4000	89.5586	.7307	.	.8023
VAR00023	47.9667	91.7575	.6703	.	.8062
VAR00024	47.6333	87.6195	.6527	.	.8036

Scale Scale Corrected

	Mean if Item Deleted	Variance if Item Deleted	Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
VAR00025	47.8333	101.4540	.1175	.	.8285
VAR00026	46.7000	99.8724	.3358	.	.8204
VAR00027	47.3000	99.0448	.2926	.	.8215

Reliability Coefficients 27 items

Alpha = .8249 Standardized item alpha = .8146

ADHD Symptoms Inventory (ADHD-SI; Cox, D.J., 1998), for parent

N of cases = 30.0

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
VAR00001	23.2667	28.2713	.4695	.6835	.7851
VAR00002	23.5333	28.7402	.2789	.7096	.7952
VAR00003	23.3333	29.8161	.1474	.5331	.8019
VAR00004	23.1000	29.2655	.3132	.6461	.7930
VAR00005	23.3000	29.3897	.2167	.6331	.7982
VAR00006	23.3333	28.7816	.2794	.7664	.7951
VAR00007	23.4333	27.9092	.3177	.7615	.7940
VAR00008	23.0667	28.9609	.3922	.6247	.7897
VAR00009	23.5333	29.0161	.2105	.7498	.8003
VAR00010	23.4000	26.5931	.5768	.7783	.7755
VAR00011	23.4667	26.1195	.6104	.8156	.7723
VAR00012	23.6000	26.4552	.6095	.7495	.7734
VAR00013	23.7667	28.3230	.3607	.5534	.7901
VAR00014	23.4667	27.3609	.4721	.7804	.7828
VAR00015	23.4667	27.2230	.3817	.6879	.7895
VAR00016	23.6333	28.3092	.3045	.6814	.7941
VAR00017	23.4667	27.0161	.4405	.7436	.7847
VAR00018	23.4333	27.0816	.4633	.6640	.7830

Reliability Coefficients 18 items

Alpha = .7984 Standardized item alpha = .7992

ADHD Symptoms Inventory (ADHD-SI; Cox, D.J., 1998), for teacher

N of cases= 30.0

RELIABILITY ANALYSIS - SCALE (ALPHA)

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Alpha if Item Deleted
VAR00001	21.7000	45.4586	.2802	.8635
VAR00002	21.9333	44.4782	.3144	.8631
VAR00003	22.0333	42.7230	.4353	.8588
VAR00004	21.6000	46.7310	.0780	.8701
VAR00005	21.7667	46.0471	.1395	.8692
VAR00006	21.7000	44.7000	.3018	.8634
VAR00007	21.9333	44.4782	.2593	.8664
VAR00008	21.5667	43.9782	.4629	.8578
VAR00009	21.9667	46.2402	.1584	.8672
VAR00010	21.9000	41.3345	.6335	.8500
VAR00011	22.0000	41.2414	.6270	.8502
VAR00012	22.2667	40.4092	.6390	.8491
VAR00013	22.3000	40.7000	.7316	.8460
VAR00014	21.9667	40.6540	.7373	.8458
VAR00015	22.1000	40.8517	.5493	.8536
VAR00016	22.1667	41.0402	.5943	.8514
VAR00017	21.9333	39.5816	.7939	.8421
VAR00018	22.1333	40.2575	.6214	.8498

Reliability Coefficients

N of Cases = 30.0 N of Items = 18

Alpha = .8639

Tables of Percent Agreement

Parent's and Teacher's Percent Agreement of ADHD Index

Child	ADHD Index				
	Parent	R1*	Teacher	R2*	% Agreement
1	80	ADHD	81	ADHD	100
2	65	ADHD	68	ADHD	100
3	72	ADHD	77	ADHD	100
4	81	ADHD	82	ADHD	100
5	69	ADHD	69	ADHD	100
6	70	ADHD	74	ADHD	100
7	87	ADHD	89	ADHD	100
8	66	ADHD	63	ADHD	100
9	66	ADHD	68	ADHD	100
10	83	ADHD	88	ADHD	100
11	64	ADHD	73	ADHD	100
12	72	ADHD	69	ADHD	100
13	80	ADHD	80	ADHD	100
14	75	ADHD	80	ADHD	100
15	78	ADHD	76	ADHD	100
16	63	ADHD	67	ADHD	100
17	88	ADHD	84	ADHD	100
18	82	ADHD	85	ADHD	100
19	69	ADHD	71	ADHD	100
20	74	ADHD	71	ADHD	100
21	58	ADHD	59	ADHD	100
22	60	ADHD	58	ADHD	100
23	73	ADHD	79	ADHD	100
24	69	ADHD	68	ADHD	100
25	59	ADHD	61	ADHD	100
26	70	ADHD	72	ADHD	100
27	80	ADHD	80	ADHD	100
28	64	ADHD	66	ADHD	100
29	66	ADHD	70	ADHD	100
30	87	ADHD	84	ADHD	100

* = T score of rating. If the score was more that 50, it mean that child have been rated as ADHD child

Parent's and Teacher's Percent Agreement of DSM-IV: Hyperactive-Impulsive

Child	DSM-IV: Hyperactive-Impulsive				
	Parent	Hyperactivity-Impulsive *	Teacher	Hyperactivity-Impulsive*	% Agreement
1	82	Yes	85	Yes	100
2	55	Yes	59	Yes	100
3	77	Yes	75	Yes	100
4	60	Yes	62	Yes	100
5	49	No	48	No	100
6	47	No	49	No	100
7	56	Yes	57	Yes	100
8	61	Yes	67	Yes	100
9	72	Yes	80	Yes	100
10	63	Yes	65	Yes	100
11	84	Yes	86	Yes	100
12	80	Yes	81	Yes	100
13	50	Yes	52	Yes	100
14	49	No	49	No	100
15	38	No	40	No	100
16	47	No	45	No	100
17	54	Yes	53	Yes	100
18	67	Yes	70	Yes	100
19	66	Yes	68	Yes	100
20	83	Yes	84	Yes	100
21	52	Yes	56	Yes	100
22	68	Yes	71	Yes	100
23	79	Yes	80	Yes	100
24	71	Yes	76	Yes	100
25	45	No	49	No	100
26	69	Yes	72	Yes	100
27	75	Yes	73	Yes	100
28	84	Yes	86	Yes	100
29	82	Yes	85	Yes	100
30	62	Yes	68	Yes	100

* = T score of rating. If the score was more that 50, it mean that child have been rated as ADHD child of DSM-IV: Hyperactive-Impulsive criterion.

Parent's and Teacher's Percent Agreement of DSM-IV: Inattentive Type

Child	DSM-IV: Inattentive Type				
	Parent	Inattentive *	Teacher	Inattentive *	% Agreement
1	72	Yes	73	Yes	100
2	56	Yes	59	Yes	100
3	40	No	41	No	100
4	45	No	42	No	100
5	86	Yes	87	Yes	100
6	89	Yes	82	Yes	100
7	48	No	45	No	100
8	62	Yes	61	Yes	100
9	59	Yes	56	Yes	100
10	58	Yes	53	Yes	100
11	67	Yes	63	Yes	100
12	43	No	47	No	100
13	46	No	49	No	100
14	83	Yes	88	Yes	100
15	87	Yes	89	Yes	100
16	84	Yes	87	Yes	100
17	47	No	44	No	100
18	49	No	47	No	100
19	42	No	47	No	100
20	53	Yes	59	Yes	100
21	62	Yes	60	Yes	100
22	73	Yes	76	Yes	100
23	79	Yes	80	Yes	100
24	45	No	46	No	100
25	87	Yes	89	Yes	100
26	47	No	49	No	100
27	68	Yes	65	Yes	100
28	71	Yes	68	Yes	100
29	48	No	46	No	100
30	72	Yes	70	Yes	100

* = T score of rating. If the score was more that 50, it mean that child have been rated as ADHD child with predominantly inattentive type.

Tables of Item Difficulties

Mathematic Activity 1				Mathematic Activity 2				Mathematic Activity 3			
No.	n of High Score	n of Low Score	P	No.	n of High Score	n of Low Score	P	No.	n of High Score	n of Low Score	P
1	12	11	0.66	1	11	8	0.54	1	15	11	0.74
2	13	10	0.66	2	14	10	0.69	2	12	7	0.54
3	11	8	0.54	3	11	6	0.49	3	13	10	0.66
4	14	10	0.69	4	13	10	0.66	4	10	6	0.46
5	9	6	0.43	5	14	11	0.71	5	12	9	0.60
6	11	9	0.57	6	15	13	0.80	6	11	7	0.51
7	13	7	0.57	7	12	11	0.66	7	10	5	0.43
8	10	7	0.49	8	10	7	0.49	8	13	9	0.63
9	10	7	0.49	9	11	8	0.54	9	14	11	0.71
10	9	5	0.40	10	13	7	0.57	10	14	12	0.74
11	10	6	0.46	11	10	5	0.43	11	15	10	0.71
12	14	11	0.71	12	12	9	0.60	12	12	9	0.60
13	12	9	0.60	13	10	7	0.49	13	11	8	0.54
14	12	8	0.57	14	13	11	0.69	14	10	6	0.46
15	10	5	0.43	15	11	10	0.60	15	14	12	0.74
16	11	5	0.46	16	11	7	0.51	16	13	9	0.63
17	12	9	0.60	17	10	5	0.43	17	12	7	0.54
18	13	6	0.54	18	14	10	0.69	18	10	6	0.46
19	12	9	0.60	19	12	8	0.57	19	10	6	0.46
20	12	8	0.57	20	12	7	0.54	20	13	10	0.66
21	10	6	0.46	21	11	5	0.46	21	11	7	0.51
22	11	9	0.57	22	13	9	0.63	22	14	11	0.71
23	10	4	0.40	23	14	11	0.71	23	12	10	0.63
24	9	6	0.43	24	13	10	0.66	24	10	6	0.46
25	15	10	0.71	25	11	5	0.46	25	13	11	0.69
26	11	7	0.51	26	12	8	0.57	26	11	7	0.51
27	14	9	0.66	27	16	12	0.80	27	14	11	0,71
28	12	10	0.63	28	15	13	0.80	28	12	7	0.54
29	13	7	0.57	29	14	10	0.69	29	15	10	0.71
30	9	5	0.40	30	15	12	0.77	30	15	11	0.74

Mathematic Activity 4				Mathematic Activity 5				Mathematic Activity 3			
No.	n of High Score	n of Low Score	P	No.	n of High Score	n of Low Score	P	No.	n of High Score	n of Low Score	P
1	14	11	0.71	1	13	10	0.63	1	11	7	0.514
2	12	10	0.63	2	10	7	0.49	2	12	10	0.629
3	13	11	0.69	3	11	9	0.57	3	10	7	0.486
4	15	12	0.77	4	14	12	0.74	4	13	11	0.686
5	11	9	0.57	5	13	11	0.69	5	10	5	0.429
6	10	4	0.40	6	15	13	0.80	6	12	9	0.60
7	12	7	0.54	7	13	11	0.69	7	14	9	0.657
8	12	9	0.60	8	10	7	0.49	8	15	11	0.743
9	13	11	0.69	9	12	7	0.54	9	11	9	0.571
10	10	6	0.46	10	12	8	0.57	10	13	8	0.60
11	11	7	0.51	11	9	6	0.43	11	13	7	0.571
12	11	5	0.46	12	14	13	0.77	12	14	10	0.686
13	15	10	0.71	13	11	8	0.54	13	10	6	0.457
14	13	7	0.51	14	10	6	0.46	14	9	6	0.429
15	10	6	0.41	15	12	10	0.63	15	13	8	0.60
16	9	8	0.49	16	13	10	0.66	16	10	6	0.457
17	13	10	0.66	17	11	7	0.51	17	14	12	0.743
18	12	8	0.57	18	14	11	0.71	18	11	7	0.514
19	10	7	0.49	19	10	6	0.46	19	12	6	0.514
20	11	6	0.49	20	12	10	0.63	20	13	10	0.657
21	14	10	0.69	21	11	7	0.51	21	15	13	0.80
22	13	9	0.63	22	12	8	0.57	22	10	4	0.40
23	15	12	0.77	23	15	12	0.77	23	13	10	0.657
24	10	7	0.49	24	14	12	0.74	24	11	6	0.486
25	12	8	0.57	25	10	6	0.46	25	14	10	0.686
26	14	10	0.69	26	11	7	0.51	26	10	7	0.486
27	13	7	0.57	27	14	10	0.69	27	13	11	0.686
28	15	10	0.71	28	13	11	0.69	28	11	8	0.543
29	14	11	0.71	29	15	12	0.77	29	11	7	0.514
30	10	7	0.49	30	13	10	0.66	30	12	8	0.571

* P = Item Difficulties

Tables of Items Difficulties

Mathematamatic Activity 7				Mathematic Activity 8				Mathematic Activity 9			
No.	n of High Score	n of Low Score	P	No.	n of High Score	n of Low Score	P	No.	n of High Score	n of Low Score	P
1	14	10	0.69	1	12	6	0.51	1	13	11	0.69
2	12	10	0.63	2	12	9	0.60	2	10	5	0.43
3	13	9	0.63	3	10	5	0.43	3	12	8	0.57
4	10	5	0.43	4	13	11	0.69	4	11	8	0.54
5	11	7	0.51	5	14	9	0.66	5	14	9	0.66
6	13	9	0.63	6	11	9	0.57	6	11	9	0.57
7	13	11	0.69	7	13	10	0.66	7	13	10	0.66
8	12	7	0.54	8	12	11	0.66	8	12	4	0.46
9	13	10	0.66	9	12	9	0.60	9	12	9	0.60
10	12	8	0.57	10	14	12	0.74	10	10	6	0.46
11	10	6	0.46	11	11	8	0.54	11	15	8	0.66
12	10	6	0.46	12	12	9	0.60	12	12	4	0.46
13	11	7	0.51	13	14	11	0.71	13	12	8	0.57
14	12	9	0.60	14	10	6	0.46	14	10	6	0.46
15	15	12	0.77	15	12	10	0.63	15	15	12	0.77
16	13	10	0.66	16	11	7	0.51	16	13	10	0.66
17	11	9	0.57	17	13	9	0.63	17	12	6	0.51
18	10	7	0.49	18	10	8	0.51	18	14	9	0.66
19	15	11	0.74	19	10	9	0.54	19	10	5	0.43
20	12	8	0.57	20	14	13	0.77	20	11	8	0.54
21	14	10	0.69	21	15	13	0.80	21	9	5	0.40
22	11	8	0.54	22	13	10	0.66	22	11	8	0.54
23	15	13	0.80	23	11	8	0.54	23	13	10	0.66
24	13	10	0.66	24	10	5	0.43	24	12	7	0.54
25	15	10	0.71	25	13	10	0.66	25	10	8	0.51
26	14	12	0.74	26	15	12	0.77	26	11	7	0.51
27	12	8	0.57	27	14	10	0.69	27	12	7	0.54
28	14	11	0.71	28	11	9	0.57	28	14	11	0.71
29	13	7	0.57	29	12	10	0.63	29	13	11	0.69
30	9	5	0.40	30	13	8	0.60	30	11	6	0.49

* P = Item difficulties

Table of Items Dfficulties

Mathematic Activity 10			
No.	**n of High Score**	**n of Low Score**	**P**
1	14	12	0.74
2	11	9	0.57
3	12	10	0.63
4	10	7	0.49
5	9	6	0.43
6	16	10	0.74
7	13	11	0.69
8	11	8	0.54
9	14	12	0.74
10	14	10	0.69
11	12	9	0.60
12	10	4	0.40
13	9	6	0.43
14	11	5	0.46
15	15	8	0.66
16	10	5	0.43
17	11	7	0.51
18	13	10	0.66
19	12	8	0.57
20	10	8	0.51
21	13	6	0.54
22	10	7	0.49
23	11	4	0.43
24	14	11	0.71
25	10	8	0.51
26	12	10	0.63
27	14	11	0.71
28	11	9	0.57
29	13	9	0.63
30	9	7	0.46

*p = Item Difficulties

Tables for Mathematics Scores of Children In Experimental Group

Mathematics Scores of Children in Experimental Group on Baseline Phase

Child	Day 1	Day 2	Day 3	Day 4	Day 5
	Scores*	Scores*	Scores*	Scores*	Scores*
A	10	9	4	8	0
B	13	11	3	6	0
C	11	10	9	12	10

* Note: The set point score was 30.

Mathematics Scores of Children in Experimental Group on Treatment Phase

Child	Day 1	Day 2	Day 3	Day 4	Day 5
	Scores*	Scores*	Scores*	Scores*	Scores*
A	11	13	9	12	15
B	14	12	15	11	15
C	11	13	14	12	15
Child	Day 6	Day 7	Day 8	Day 9	Day 10
	Scores*	Scores*	Scores*	Scores*	Scores*
A	18	16	19	19	20
B	18	16	19	19	20
C	18	17	19	23	21
Child	Day 11	Day 12	Day 13	Day 14	Day 15
	Scores*	Scores*	Scores*	Scores*	Scores*
A	24	21	23	26	25
B	24	21	23	26	25
C	20	24	26	24	23
Child	Day 16	Day 17	Day 18	Day 19	Day 20
	Scores*	Scores*	Scores*	Scores*	Scores*
A	25	24	22	19	27
B	22	23	20	27	26
C	25	25	26	27	29

Mathematics Scores of Children in Experimental Group on Followed-up Phase

Child	Day 26	Day 27
	Scores*	Scores*
A	26	28
B	22	24
C	28	27

Figures17-19 of Mathematics Scores of Children in Experimental Group

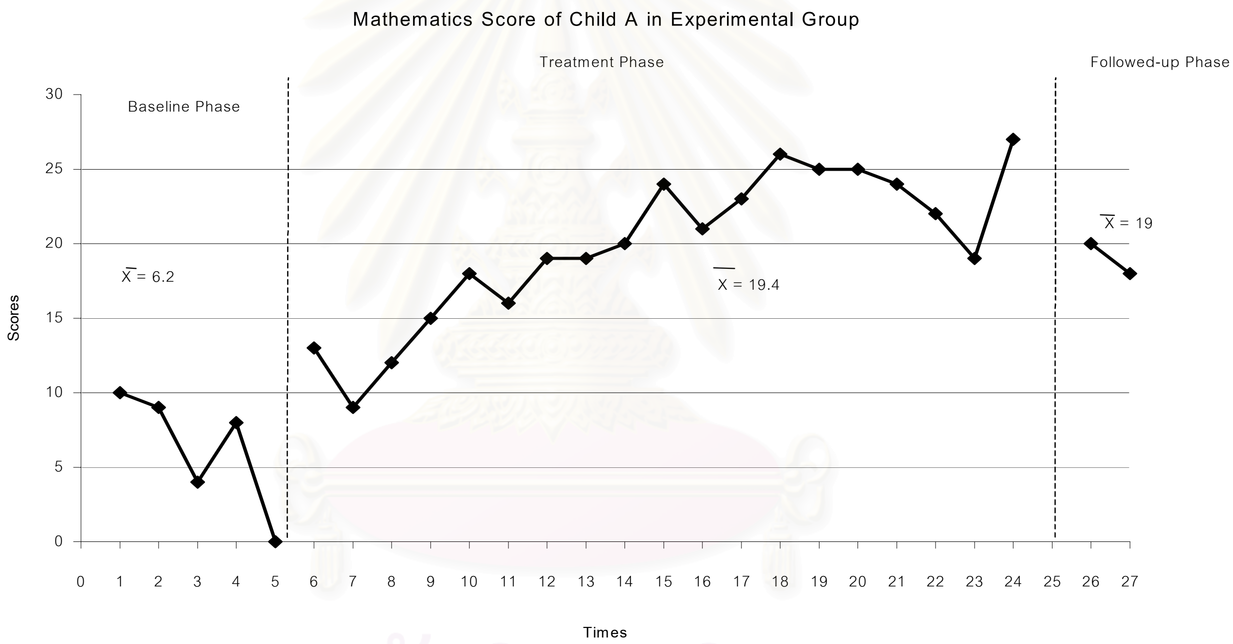

Fig.17 Means of mathematics scores of Child A in experimental group. The mean on baseline phase is 6.20 points, the mean on treatment phase is 19.40 points, and the mean on followed-up phase is 19.00 points.

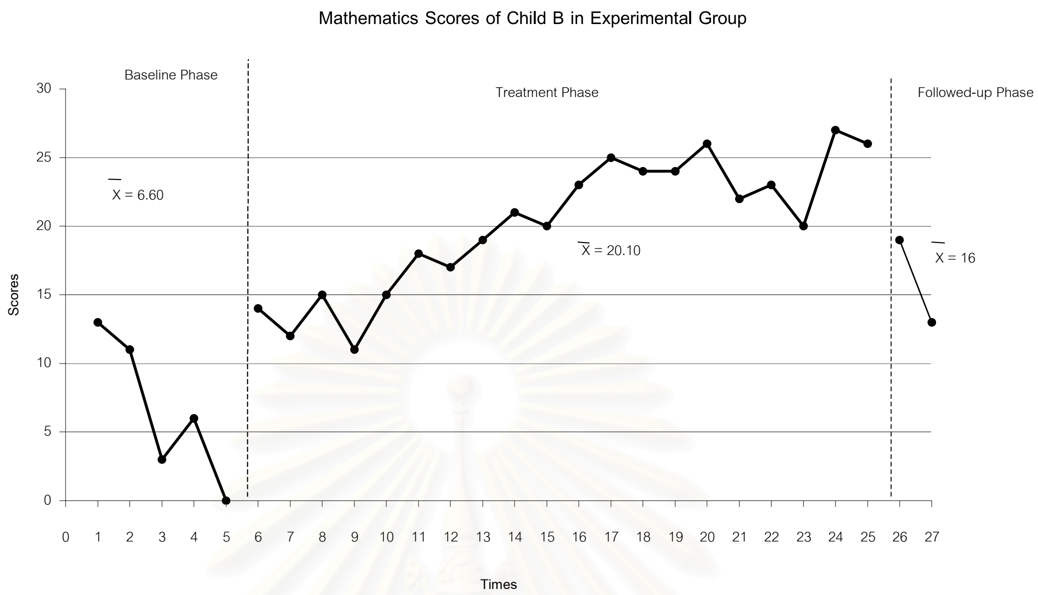

Fig.18 Means of mathematics scores of Child B in experimental group. The mean on baseline phase is 6.60 points, the mean on treatment phase is 20.10 points, and the mean on followed-up phase is 16.00 points.

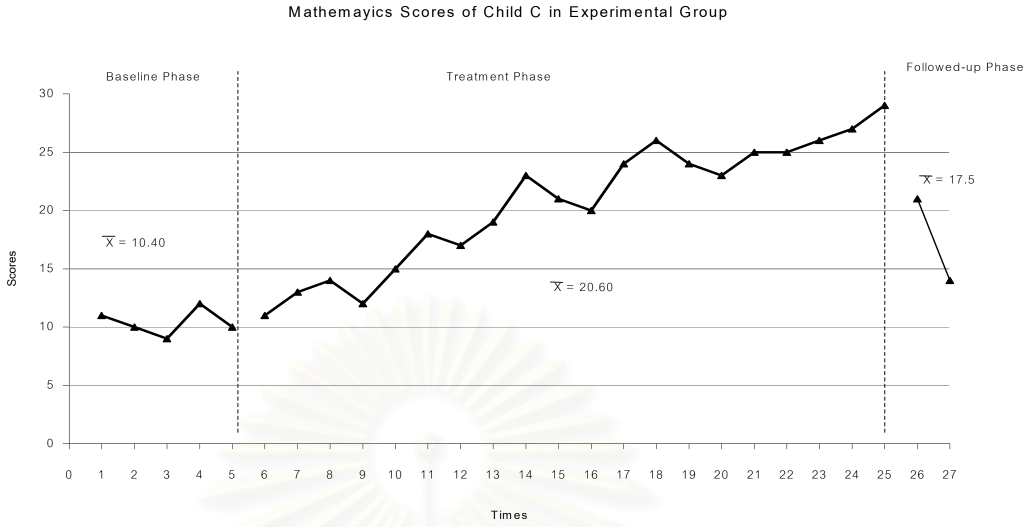

Fig.19 Means of mathematics scores of Child C in experimental group. The mean on baseline phase is 10.40 points, the mean on treatment phase is 20.60 points, and the mean on followed-up phase is 17.50 points.

Table of Intervals of Participants' Attentional Behaviors in Experimental Group during Home-Based Treatment

(8 sessions: 5sessions by the researcher, 3 sessions by their parents)

Child	Researcher					Parents		
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
A	50	54	57	56	55	50	52	51
B	56	58	55	57	56	51	52	50
C	55	58	57	56	52	50	49	53
Mean	53.67	56.67	56.33	56.33	54.33	50.33	51.00	51.33

Frequencies Table of Parents' Behaviors of Participants in Experimental Group during Home-Based Treatment

Behaviors	Parent of Child A	Parent of Child B	Parent of Child C	Total Mean
Suggestion	5	3	5	4.33
Praise	13	16	18	15.67
Blaming	2	4	3	3.00

The data showed that parents used praise ($\overline{X}$= 15.67 times)while treating their children more than suggestion ($\overline{X}$= 15.67 times) and blaming ($\overline{X}$= 15.67 times). It means parents try to used positive feedback on their children's behaviors. However, they also blame their children when they do not behave attentional behaviors.

Appendix E

Behavior Checklist

แบบบันทึกพฤติกรรมตั้งใจทำกิจกรรมคณิตศาสตร์

ชื่อผู้ถูกสังเกต____________________ วันที่สังเกต____/________/______ เวลา:______________________

ผู้สังเกต:__________________________________ สถานที่:____

พฤติกรรมตั้งใจทำกิจกรรมคณิตศาสตร์

1. มองโจทย์คณิตศาสตร์จากกิจกรรมคณิตศาสตร์ที่ผู้วิจัยกำหนดให้ในระยะห่างประมาณ 1 ฟุต
2. อ่านโจทย์จากกิจกรรมคณิตศาสตร์
3. จับปากกาหรือดินสอ และเขียนสิ่งที่กำลังคิดคำนวณลงในกระดาษโน้ตที่เตรียมไว้ให้ หรือท่องสูตรคูณและ/หรือทดเลขปากเปล่า
4. จับปากกาหรือดินสอเขียนคำตอบลงในกระดาษคำตอบที่เตรียมไว้ให้

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1 2 3 4 5 6 7 8 9 10

15 20

25 30

รวม | |
|---|

<u>**หมายเหตุ**</u> **สังเกต 20 วินาที บันทึก 10 วินาที**

Appendix F

Consent Form

เรียน ท่านผู้ปกครอง (ชื่อเด็กนักเรียน)

เนื่องด้วยดิฉันนางสาวสุภลัคน์ ลวดลาย นิสิตปริญญามหาบัณฑิตสาขาวิชาจิตวิทยาพัฒนาการ บัณฑิตวิทยาลัย จุฬาลงกรณ์มหาวิทยาลัย กำลังดำเนินการวิจัยเรื่อง “ผลของการให้ข้อมูลป้อนกลับทางชีวภาพแบบคลื่นสมองต่อพฤติกรรมตั้งใจทำกิจกรรมคณิตศาสตร์ของเด็กสมาธิสั้นและมีพฤติกรรมไม่อยู่นิ่ง” โดยมีรองศาสตราจารย์ ดร.สมโภชน์ เอี่ยมสุภาษิต เป็นอาจารย์ที่ปรึกษา ทั้งนี้ ดิฉันได้รับความร่วมมือจากทางโรงเรียนอนุญาตให้ดำเนินการทดลอง เพื่อนำผลที่ได้มาเป็นข้อมูลในการวิจัย โดยมีนักเรียนที่เข้าร่วมการวิจัยจำนวน 6 คน และ (ชื่อนักเรียน) เป็นหนึ่งในผู้ได้รับการคัดเลือกให้ร่วมการวิจัย ดิฉันจึงเรียนมาเพื่อขอให้ท่านผู้ปกครองได้โปรดอนุญาตให้เด็กของท่านได้เข้าร่วมการวิจัยครั้งนี้

การทดสอบครั้งนี้จะใช้เวลาไม่เกิน 5 สัปดาห์ โดยจัดขึ้นในช่วงปิดภาคการศึกษาเพื่อไม่ให้รบกวนเวลาเรียนของเด็ก ดิฉันขอรับรองว่าการวิจัยครั้งนี้ไม่มีอันตรายต่อเด็กและผลที่ได้จากการวิจัยจะไม่นะมาเปิดเผยต่อสาธารณชน และขอขอบพระคุณท่านเป็นอย่างสูงมา ณ โอกาสนี้

ด้วยความเคารพ

นางสาวสุภลัคน์ ลวดลาย

ขอรับรองว่าข้อความข้างต้นนี้เป็นความจริงทุกประการ

(รองศาสตราจารย์ ดร.สมโภชน์ เอี่ยมสุภาษิต)
อาจารย์ที่ปรึกษาวิทยานิพนธ์

☐ ยินดีเข้าร่วมการทดลอง

☐ ไม่ยินดีให้เข้าร่วมการทดลอง เพราะ..

ลงชื่อ..

ผู้ปกครอง

Appendix G

List of Psychology Professors who provide consultation for the validity of the instrument

Psychology Professors

1. Associate Professor Penpilai Rithakananone, Ph.D.
2. Assistant Professor Panrapee Suttiwan, Ph.D.
3. Assistant Professor Niramol Chayutsahakit, M. Ed.

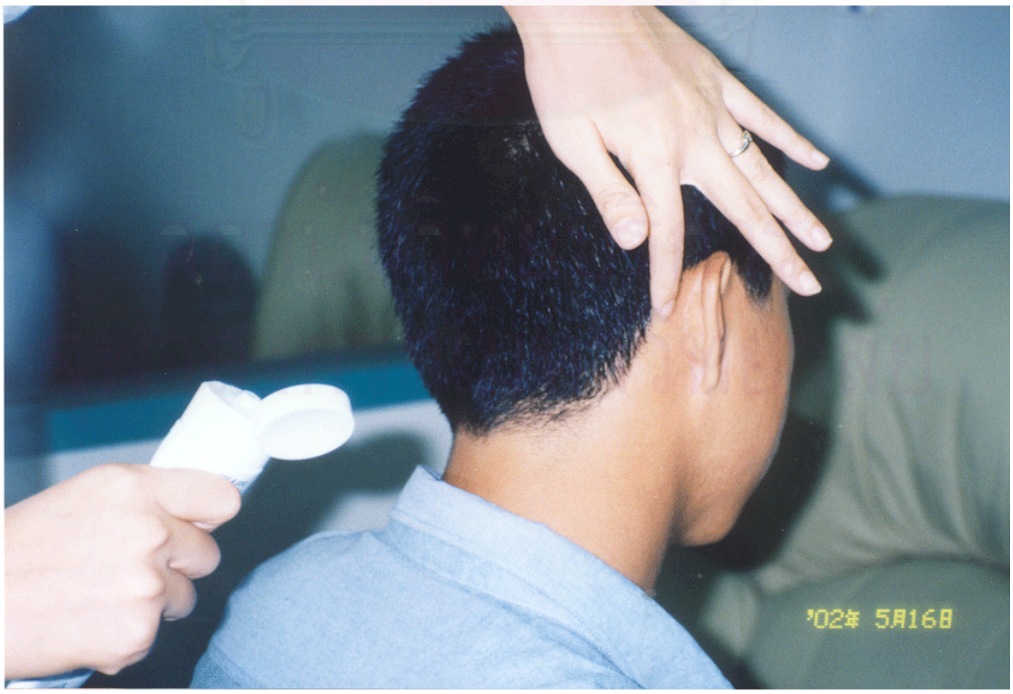
Appendix H

Laboratory Setting

Laboratory Instruments

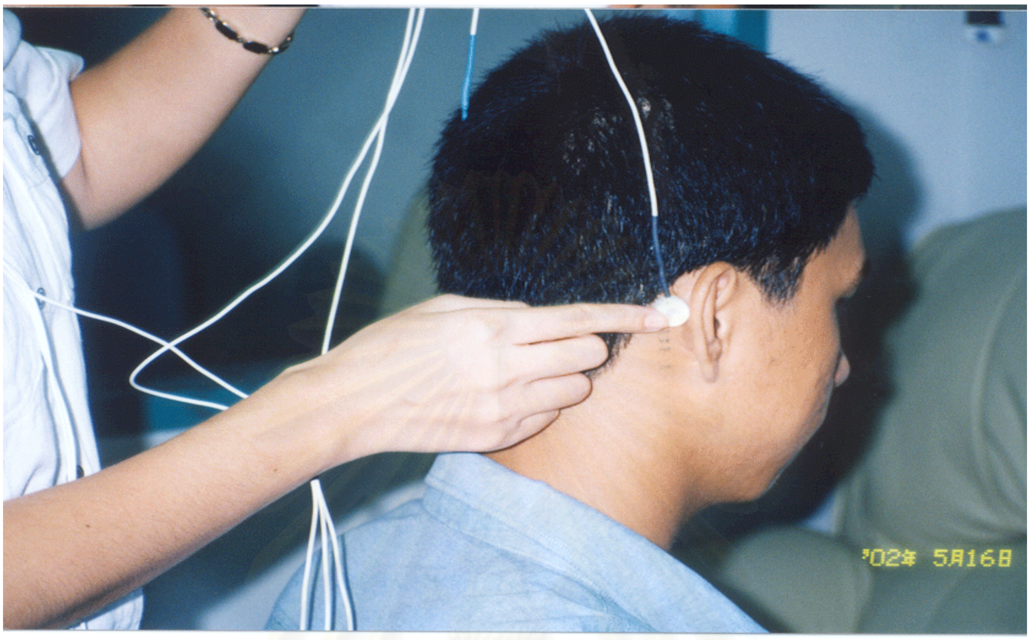
Steps of Placing EEG electrodes

Step 1 Clean the Cz point and back of the ear by using NuPrep gel.



Step 2 Place the hand ground by using gel.

Step 3 Place the electrode on Cz point and ear ground by using 10-20 gel.



Step 4 Place a tissue paper on Cz point and stick it with the grips.

Biography

Miss Supalak Luadlai was born on February 8, 1975 in Kampangphet province, Thailand. She graduated primary level from Anuban Sukhothai school in 1985 and graduated lower and upper secondary level from Phadungpanya school in 1992. Afterward, she graduated with a bechelor's degree of Education from the Department of Elementary Education, Faculty of Education, Chulalongkorn University in 1996.