

# **The Effect of Different Attributes of Stimulus for Attentional Performance of Children with Attention Deficit/Hyperactivity Disorder and Dyslexia**

## **Introduction**

Attention deficit and hyperactivity disorder (ADHD) is characterized by inattention, or impulsivity and hyperactivity, which could significantly affect daily life at school and at home (American Psychiatric Association, 2000). A particular attention deficit of children with ADHD is sustained and selective attention, which has become a successive research topic (Barkley, 1997; Slusarek, Velling, Bunk, & Eggers, 2003; Wang & Yang, 2008).

In contrast, even dyslexic children's main deficit emerge in their academic performance, abundant evidence have demonstrated that they have deficits in selective attention in alphabetic languages (Bender, 2004; Golden & Golden, 2002; Hallahan, 1989; Heiervang & Hugdahl, 2003; Sterr, 2004) and logographic languages (Gao, Zhu, Sun, & Qin, 2005; Jing, Wang, Chen, & Yang, 2004).

According to Wang, Chang, and Ho's (2011) review, both ADHD and dyslexic children showed attentional deficits, but the difference between their attentional deficits are still not very clear. Therefore, their sustained and selective attention, two of the most important attentional functions, have been examining and comparing carefully in the present study. Besides, because the elements of attentional measurements in all studies are inconsistent, the results of these studies should be explained very carefully based on the re-examination of these measurements in the present study.

### **The Definition of Sustained Attention and Selective Attention**

Attention had been considered one of the most important components necessary for learning and successful participation in the educational process (Gianvecchio & French, 2002). Sturm (1996) classified attention as four subtypes: alertness, sustained attention, selective attention, and divided attention. Among this classification, Sturm considered sustained attention as individual alertness over a long period with the ability to discern a slight change of target.

For sustained attention, Ruff, Capozzoli, & Weissberg (1998) considered sustained attention as “the ability to mobilize and maintain selectivity and concentration.” Posner and Peterson (1990) indicated sustained attention as the ability to maintain focus continuously on specific stimuli, and direct and control one’s attention innately (Reck & Hund, 2011). Gianvecchio and French (2002) defined sustained attention as a coordinate approach with other cognitive activities such as memory, motivation, and self-regulation to promote adaptation to environmental and internal demands. Some researchers have proposed that lapses of sustained attention could be detected within four minutes, by reversing the response paradigm of vigilance tasks (Robertson, Manly, Andrade, Baddeley, & Yiend, 1997). From preschoolers to adults, researchers have used methodologies that test the ability to detect targets in long sequences of irrelevant distractors to measure sustained attention (DeWolfe, Byrne, & Bawden, 1999; Conners, 2000). Performance is typically evaluated in terms of commission errors (responding to distractor stimuli) and omission errors (missing target stimuli) (Reck & Hund, 2010). Several studies have identified sustained attention as an important predictor of subsequent achievement test scores (Cobb, 1972; Frederick & Walberg, 1980).

Selective attention is defined as the ability to filter out irrelevant or distracting information from that which is more central or relevant to a given task. Findings have

consistently demonstrated that the strategies children use to selectively attend become more effective in terms of the relevant information recalled during middle childhood (Blumberg, Torenberg, & Randall, 2005). In selective attention, the control or regulation of behavior is restricted to some subset of information relevant to a current goal. The biased competition theory (Desimone & Duncan, 1995) indicates that top-down effects enhance processing for stimulus representations most relevant to current behavior, while reducing or gating this process for unwanted competing stimuli representations (Pritchard, Neumann, & Rucklidge, 2008).

### **Attentional Deficit of Children with Attention Deficit/Hyperactivity Disorders and Dyslexia**

ADHD is a common and childhood-onset psychiatric disorder defined by age-inappropriate levels of inattention, hyperactivity, or impulsivity (DSM-IV, American Psychiatric Association, 1995). Barkley suggested one of the major attention deficits of ADHD is the deficit of sustained attention, such as the inability to maintain attention to finish a task or to notice details, and the tendency to make mistakes (Barkley, 1997).

Doctors typically use stimulant medications, such as methylphenidate, for ADHD, and this medication has effectively treated the cognitive and behavioral features of the disorder. Stimulants inhibit the re-uptake and promote the release of catecholamines (including dopamine and noradrenaline) (Krause, Dresel, Krause, la Fougere, & Aclenheil, 2003). A recent study shows that one major characteristic of ADHD is variability in response time (RT) on tasks that measure sustained attention capabilities (Castellanos & Tannock, 2002). Sustained attention is the intrinsic ability to mindfully and consciously process stimuli, whose non-arousing qualities would otherwise lead to habituation and distraction (Robertson et al., 1997). The ability to sustain attention

to a task and produce an appropriate response entails the executive function. Although most researches have focused on explaining sustained attention deficits in ADHD, some researchers have argued that sustained attention deficit is due to a time-on-task effect for the number of errors (van den Bergh, Mennes, Stevens, van der Meere, B"orger, & Stiers, 2006).

Even though the major characteristic of children with dyslexia is reading, their attention problems have been examined for several years. For example, Johnson (1981) suggested that children with dyslexia typically demonstrate attention deficit in selecting objects; Bender (2004) indicated that children with dyslexia have problems in selecting something they like or not; Hallahan (1989) found that children with dyslexia could not process related information continuously, and this phenomenon might be due to their problems in excluding irrelevant objects; Bowen and Hynd (1988) used dichotic listening studies to test the selective attention of children with dyslexia, and found that children with dyslexia demonstrated delay in speed of free recall and attention orientation; Ricards, Samuels, Turnure, and Ysseldyke (1990) used the "Continuous Performance Task" and selective attentional test to examine the selective attention of children with dyslexia and found that the participant performance was significantly delayed.

Previous studies have indicated that children with dyslexia have a significant deficit in selective attention. Johnson (1981) was the first researcher who indicated the selective attention deficit of children with dyslexia. Bowen and Hynd (1988) examined Johnson's view point by dichotic listening, and they also had similar results. Instead of listening tasks, some visual tasks were used to examine selective attention of children with learning disabilities. Golden and Golden (2002) used stroop task, Heiervang and Hugdahl (2003) used visual cue-target paradigm, and Solan, Larson, Shelley-Tremblay, Silverman, and Ficcara (2001) used eye movement analysis and

Sterr (2004) used test of everyday attention for children to examine dyslexic children's attentional deficit, and the results were consistent with Bowen and Hynd's.

In addition to studies in alphabetic languages, the similar results were found in the graphic languages. For instant, Dr. Jing who is a professor and Doctor of Medicine in China and his colleagues found that children with dyslexia had some cognitive deficits included selective attention deficit in 2000. Therefore, they focused deeply on dyslexic children's selective attention in 2004, and the results of this study indicated selective attention deficit was the primary problems. Wang et al. (2011) integrated several studies from 1981 to 2008 which focused on dyslexic children's attention deficits, and they claimed that selective attention deficit was the most consistent result in these studies.

### **The Measurements of Sustained Attention and Selective Attention**

Tools were used to measure sustained attention and selective attention for many cases. For example, the Test of Everyday Attention (TEA), which was a paper-and-pencil test that uses relatively familiar everyday materials and is therefore plausible and acceptable to subjects. It was designed to probe two separable attention, called "selection system" and the "vigilance system", in the brain (Sterr, 2004). Sterr (2004) used TEA to test selective attention of children with dyslexia, and he indicated that dyslexic children performed worse than normal children in all of selective attention and attentional switching sub-tasks.

Protopapas, Archonti, and Skaloumbakas (2007) used Stroop task to test dyslexic children's selective attention, and they indicated that poorer reading skills were found to correlate with greater Stroop interference in the general school sample and interference was primarily associated with reading speed, with an additional unique contribution of reading accuracy. For the Stroop task, there were three cards were

shown to the participant. On the first card (color word subtest) the participant was asked to read a list of color names printed in black ink (yellow, blue, green and red). On the second card (color name subtest) the participant is requested to name colors printed in squares. On the last card (interference subtest) a list of color names printed in a different color ink (e.g. the word red is printed in blue) is used. The participant had to name the printed color and ignore the written word. Time was measured in all three conditions. In the last part of the test (interference subtest) both the number of mistakes and the number of self-corrections were counted.

Another task used to measure sustained attention was the sustained attention to response task (SART). In this task, participants watched single digits 1-9 appearing on the computer screen at a regular, rhythmic rate of one every 1.15 seconds. They were asked to press the same response key for each number – an action that rapidly became rather automatic and “driven” by the task, essentially, tapping along in time (Robertson et al., 1997). In the procedure, 225 single digits (25 of each of the nine digits) were presented visually over a 4.3-min. Each digit was presented for 250 milliseconds, followed by a mask for 900 milliseconds. Subjects responded with a key press to each digit when they had to withhold a response. Subjects used their preferred hand. The target digit was distributed throughout the 225 trials in a pre-fixed quasi-random fashion. The period from digit onset to digit onset was 1125 milliseconds. Subjects were asked to give equal importance to accuracy and speed in doing the task (Robertson et al., 1997). Some researchers have used this task to measure ADHD’s sustained attention, such as Robertson et al. (1997), Bellgrove, Hawi, Kirley, Gill, and Robertson (2005) and Bellgrove, Hawi, Gill, and Robertson (2006).

However, for assessing sustained attention and selective attention simultaneously, the most common tool is Continuous Performance Task (CPT). Some researchers

have used CPT to measure participants' sustained attention and selective attention (Okazaki, Maekawa, Ozaki, & Futakami, 2002; Ricards et al., 1990; Quinn, 2003; Schneider et al., 2010; Warm, 1984). The CPT might vary in terms of length and the type of stimulus used; however, the basic nature of the tests remains the same. Participants were told that they would see a series of letters presented on a screen and should click a button (or computer mouse) only when they saw the "target" stimulus. The participants were to refrain from clicking if they saw any other letter presented (Conners, 2002). Because the present study tests sustained attention and selective attention simultaneously, the chosen instrument for testing was designed by mimicking the rules and visualization of CPT.

Regardless of what type of measurement is used for sustained attention and selective attention, researchers assess participants' attentional performance. However, in real-life, people are faced with doing something they like (such as exercise and toys) and something they do not like (such as mathematics and punishment). This condition could not be measured by traditional tools such as PDTP-R and CPT.

In addition, most study used abstract objects to be the materials of attention test, but there were still some real objects were used to measure participants' attention in previous studies (e.g. Koerts, Borg, Meppelink, Leenders, van Beilen, & van Laar, 2010; Vuilleumier, Schwartz, Duhoux, & Driver, 2005), but it still lacked of comparing the effect of real and abstract objects in attention test. However, the different materials of attention test might be an important variable with strong effect.

Besides, in terms of visual attention theory which conducted by Bundesen (1990), visual recognition and attentional selection are consisted as making perceptual categorizations of elements in the visual field. When the categorization was made (entered a limited-capacity short-term-memory store), the element was both selected and recognized as a member of a particular category (Bunesen, 1990). Following,

the attribute of stimulus is very important to be noticed for persons. In the other words, there may be some differences between interesting and uninteresting classifications which stimulus are categorized into.

Therefore, we expected that if educators gave children with dyslexia and ADHD some real things they liked, they might be able to focus for a longer time. However, no research has conducted an empirical experiment on this topic. Therefore, the present study focused on comparing attentional performance of typical developing children and children with dyslexia and ADHD between geometric figures and the interesting figures.

### **Research Aims of the Present Study**

In order to examining the difference dyslexic and ADHD children's sustained and selective attention and the different attributes of stimulus for attentional performance of dyslexic and ADHD children, there were portions in the present study. First, we examined and compared typical developing, dyslexic and ADHD children's sustained and selective attention in geometric-figure version. Indeed, typical developing, dyslexic and ADHD children's sustained and selective attention had also been examined and compared in interesting-figure version. Finally, the improvements of typical developing, dyslexic and ADHD children's sustained and selective attention from interesting-figure version were also been examined.

## **Method**

### **Participants**

Thirty children with ADHD (12 girls), 30 children with dyslexia (16 girls) and 30 typical developing children (12 girls) participated in the study. The mean age of the participants with ADHD was 10:3 years (S.D. =1:1), that of participants with



dyslexia was 9:8 years (S.D. =0:11), and that of the control participants was 9:7 years (S.D. =0:9). The mean estimated full-scale IQ of the participants with ADHD, as assessed by the WISC-III, was 98.1, 99.4 for participants with ADHD and dyslexia, and 101.9 for the control participants (see Table 1).

Participants with ADHD in the present study were sampled from 94 children with ADHD, and participants with dyslexia were sampled from 99 children with dyslexia. The typical participants were matched by the sample in the other two groups. The reasons of excluding sample were area of school, chronological ages, IQ, and genders.

The pool of ADHD sample was referred from pediatricians, and the children who were identified as ADHD in the present study were not only with an IQ of at least 90 but fitted to the DSM-IV-TR Criteria for ADHD – Six or more of the symptoms of inattention / hyperactivity-impulsivity have been present for at least 6 months to a point that is disruptive and inappropriate for developmental level (American Psychiatric Association, 2000). In addition, 64.5% of them took medication during the tasks and generally.

On the other hand, the sampling criterion of dyslexia in the present study separated the children whose completed scores (“Reading Comprehension Screening Test for Elementary School” and “Chinese Reading Comprehension Test”) were below the 0.1 standard deviation of mean. Children with an IQ of at least 90, who were below the fifteenth percentile in both reading comprehension tests, were diagnosed as dyslexic.

The possibility of avoiding the comorbidity of ADHD and dyslexia was almost 9% to 11% (Biederman, Newcorn, & Sprich, 1991; Wilens, 2008), and some methods selected samples. One method began with two reading comprehension tasks to sample dyslexic children, the “Reading Comprehension Screening Test for Elementary School (second to sixth grades)” (RCSTES, Ko & Zhan, 2006) and the “Chinese Reading Comprehension Test” (CRC, Lin & Chi, 2002). Both of these tests focused

on testing participants' reading comprehension in Chinese, RCSTES included ambiguity words, proposition combination, sentence comprehension and essay comprehension, and CRC included phonological processing, syntax, semantics, understanding the basic facts of the article, summary of focus effect, inference, and comparative analysis.

The procedure of screening the comorbidity in this sample of children for dyslexia and ADHD was using above reading comprehension tests to make sure dyslexic participants' reading deficit and exclude ADHD participants in this dimension. In addition, all participants were tested Child Behavior Checklist (CBCL), which was a parent-report questionnaire on which the child was rated on various behavioral and emotional problems for evaluating maladaptive behavioral and emotional problems in preschool subjects aged 2 to 3 or in subjects between the ages of 4 and 18, to making sure their ADHD or not. Another method to sample ADHD children, the "Multidimensional Attention Test" (MAT, Song, Qiu, & Lin, 1993), included selective attention, divided attention, and sustained attention sub-tests.

Table 1

*The integration of all participants*

	ADHD	dyslexia	typical	<i>F</i> (2,86)	posthoc
Number	30 (18M 12F)	30 (14M 16F)	30 (18M 12F)		
Age	10:3 years (SD = 1:1)	9:8 years (SD = 0:11)	9:7 years (SD = 0:10)	0.71	
WISC-III FIQ	98.1	99.4	101.9	6.24	
WISC-III VIQ	101.5	97.7	102.7	4.17	
WISC-III PIQ	92.5	100.4	100.4	8.63	
RCSTES	51.7	31.2	59.4	18.92*	dyslexia < ADHD = typical
CRC	74.8	49.2	81.8	35.87**	dyslexia < ADHD = typical
CBCL	93.5	36.2	28.9	41.66**	ADHD > dyslexia = typical
MAT	32.1	71.2	81.5	54.22**	ADHD < dyslexia = typical

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*Note.* Scores of RCSTES, CRC and CBCL were transformed to *t* scores. RCSTES: Reading Comprehension Screening Test for Elementary School, CRC: Chinese Reading Comprehension Test, CBCL: Child Behavior Checklist. MAT: Multidimensional Attention Test

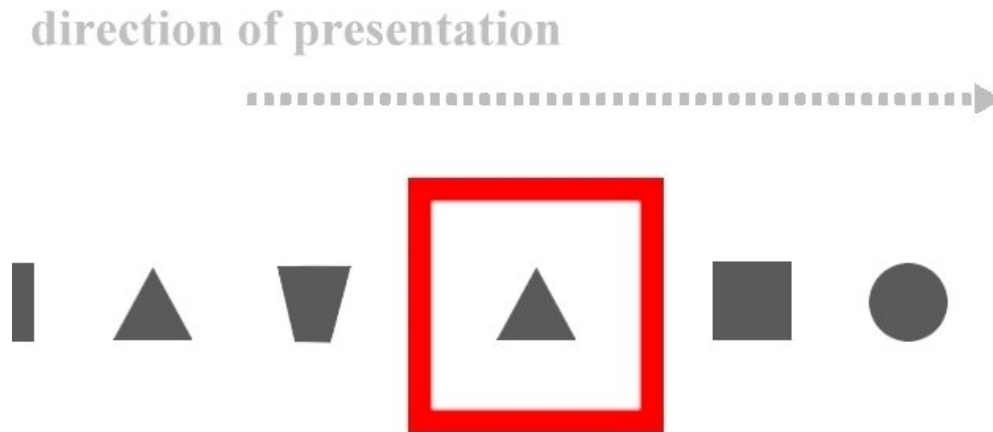
\* $p < .05$ . \*\* $p < .01$ .

## **Measurement**

A sustained attention and selective attention measurement to test these constructs in a geometric-figure version and an interesting-figure version by Adobe Flash Professional CS4 version was designed by the author. The test began with one red hollow square in the center of the white background on the screen and the stimulus presented sequentially from right to left. Participants were asked to push the button when they saw the target passing the red hollow square. One of the cases included one kind of target and three kinds of distractor.

This measurement included two versions, the geometric-figure version and the interesting-figure version. Simply, the author put four stable images in the geometric-figure version including square, circle, trapezium, and triangle, and each target was different for every participant. In the case of the interesting-figure version, included house, cat, hand, and tree, and each target was different for every participant.

The scores of this measurement were separated into omission error and commission error. The first one (omission error) measured sustained attention (Carriere, Cheyne, Solman, & Smilek, 2010), and the second one (commission error) measured selective attention (Noland et al., 2003). The instrument sample in the present study is shown as Figure 1.



*Figure 1* The presentation on the screen of the measurement

The figure shows a sequence of objects presented dynamically from right to left. Participants were asked to respond when the object was in the red box in the center of screen. If participants did not respond when the target was in the red box, it would be counted as omission error. If participants responded incorrectly when the distractor was in the red box, it would be counted as commission error. The time intervals of all procedures for both the geometric-figure version and the interesting-figure version were four minutes.

Thirty other typical developing children joined into prior test of this measurement to conduct the re-test reliability (time interval was four weeks), and re-test reliability of sustained attention and selective attention of geometric-figure version were .89 and .94. The convergent validity of this measurement was used another standardized test, called “Multi-dimensional Attention Test” (Zhou, Qiu, & Song, 1993), and the result showed the convergent validity of sustained attention and selective attention of geometric-figure version were .64 and .59.

## **Procedure**

The authors of the present study constructed the attentional test for research purposes; therefore, some procedures examined the reliability and validity. Thirty normal fourth grade children were tested two times (at four month intervals) to examine the re-test reliability. The re-test reliability of sustained attention was 0.85 and selective attention was 0.81, an acceptable result. The same thirty children were tested by Conners' Continuous Performance Test II (Ver. 5) and the Trail Making Test (TMT) for sustained attention and selective attention to examine the convergent validity of the present test. The results showed 0.74 of sustained attention and 0.69 of selective attention.

In the research portion, participants needed to respond when the target showed on the screen, and did not respond when the distractors were shown. After this session, all participants took a 30-minute rest to reduce fatigue. During their rest time, there was no any violent activity they attended to avoid they become too exciting to affect the validity of results. Before starting the interesting-figure version, the targets and distractors were replaced by interesting objects. Participants were asked to repeat what they did in the first part, even though the objects on the screen were different.

## **Results**

The present study examined the effect of different attributes of stimulus for attentional performance of typical developing children and children with ADHD and dyslexia. The results of the current study can be separated into three portions: (1) sustained attention and selective attention of typical developing children and children with ADHD and dyslexia in geometric-figure version, (2) sustained attention and selective attention of typical developing children and children with ADHD and

dyslexia in interesting-figure version, and (3) comparison of the effect of different attributes of stimulus for sustained attention and selective attention of typical developing children and children with ADHD and dyslexia.

### **Sustained attention and selective attention of typical developing children and children with ADHD and dyslexia in the geometric-figure version**

An ANOVA test was used to examine sustained attention and selective attention of typical developing children and children with ADHD and dyslexia in the geometric-figure version. The results are shown in Table 2.

Table 2

*Performance of sustained attention and selective attention of all participants in the geometric-figure version*

	typical group		ADHD group		dyslexia group		<i>F</i> (2, 86)	Post hoc
	M	SD	M	SD	M	SD		
omission errors	3.57	1.52	14.60	2.22	4.50	1.13	393.87**	normal < ADHD dyslexia < ADHD normal = dyslexia
commission errors	3.50	1.45	11.67	2.11	10.30	1.70	200.16**	normal < ADHD ADHD = dyslexia normal < dyslexia

*Note.* N = 30 for all groups

\*  $p < .05$ . \*\* $p < .01$ .

As Table 2 shows, typical and dyslexic children performed better than ADHD children in omission errors (sustained attention) and performed similarly in commission errors (selective attention). Therefore, the geometric-figure version results of the present study are similar to previous related studies (Bellgrove et al., 2006; Bender, 2004; Golden & Golden, 2002; Hallahan, 1989; Kieling, Roman, Doyle, Hutz, & Rohde, 2006; Manly et al., 2002; Ricards et al., 1990). This means that participants in the present study were suitable to examine this issue. Therefore, the

next step of the present study is to examine the effect of interesting objects of attentional performance.

### **Sustained attention and selective attention of typical developing children and children with ADHD and dyslexia in interesting-figure version**

An ANOVA test used to examine sustained attention and selective attention of typical developing children and children with ADHD and dyslexia in the interesting-figure version. The results are shown in Table 3.

Table 3

*Performance of sustained attention and selective attention of all participants in the interesting-figure version*

	typical group		ADHD group		dyslexic group		$F(2, 86)$	Post hoc (Bonferroni)
	M	SD	M	SD	M	SD		
omission errors	3.30	1.31	6.72	1.50	3.80	1.21	7.837*	typical < ADHD dyslexia < ADHD typical = dyslexia
commission errors	2.93	1.14	10.26	2.04	4.27	1.13	247.39**	typical < ADHD dyslexia < ADHD typical = dyslexia

*Note.* N = 30 for all groups

\*  $p < .05$ . \*\*  $p < .01$ .

Table 3 above shows several differences from Table 1. In omission errors, dyslexic children performed similarly to typical and ADHD children, but children with ADHD performed significantly worse than typical developing children in this dimension. All children performed similarly in commission errors.

### **Effect of different attributes of stimulus for sustained attention and selective attention of typical developing children and children with ADHD and dyslexia**

The results above indicate some differences between Table 2 and Table 3. However,

it was necessary to examine the difference between the geometric-figure version and the interesting-figure, and the Paired-Samples  $t$  test and Cohen's  $d$  method of effect size were used to examine it. The Paired-Samples  $t$ -test results of comparison of omission errors and commission errors of geometric-figure version and interesting-figure version in all groups, and the Cohen's  $d$  results of the geometric-figure version and the interesting-figure version in sustained attention and selective attention of typical developing children and children with ADHD and dyslexia are shown in Table 4.

Table 4

*Comparison and Effect Size of two versions in sustained attention and selective attention of all participants*

	geometric-figure version		interesting-figure version		$T$ value	Cohen's $d$
	omission errors		omission errors			
	M	SD	M	SD		
typical group	3.57	1.52	3.30	1.32	1.61	0.25
ADHD group	14.60	2.22	4.27	1.51	19.56**	4.17
dyslexia group	4.50	1.14	3.80	1.12	2.39*	0.60

	geometric-figure version		interesting-figure version		$T$ value	Cohen's $d$
	commission errors		commission errors			
	M	SD	M	SD		
typical group	3.50	1.46	2.93	1.43	2.43*	0.44
ADHD group	11.60	2.11	10.27	1.87	3.28*	0.68
dyslexia group	11.30	1.71	3.43	1.14	23.75**	4.34

*Note.*  $N = 30$  for all groups

\*  $p < .05$ . \*\*  $p < .01$ .

Table 4 shows the results of the Paired-Samples  $t$ -test at first. In this portion, only omission errors of typical developing group did not show significantly difference between geometric-figure version and interesting-figure. It was just able to claim that



the interesting-figure version showed some effect in statistic, but it did not mean that all other five portions (including omission errors of ADHD and dyslexia group and commission errors of three groups) had the same effect. Therefore, the results of Cohen's  $d$  were more important to show that. According to the results of Cohen's  $d$ , the biggest effect sizes were omission errors of ADHD children and commission errors of dyslexic children. In other words, the interesting-figure version showed significantly good effect of ADHD children's sustained attention and dyslexic children's selective attention. In terms of Cohen's (1992) conventional criterion of effect size, 0.2 was small size, 0.5 was medium size, and 0.8 was big size. Therefore, the effect size of omission errors of dyslexic children and commission errors of ADHD children were medium size. The interesting-figure version showed good effect of ADHD children's selective attention and dyslexic children's sustained attention. Furthermore, 0.25 and 0.44 did not achieve the criterion of medium size, so the interesting-figure version showed a small effect of normal children's sustained and selective attention.

## Discussion

Using interesting figures was taken as a method to increase attentional performance of someone who has attention deficit. However, the lack of related evidence about this issue formed the purpose of the present study. The results of the present study can be integrated as Table 5.

Table 5

*Results of two versions in sustained attention and selective attention of all participants*

	geometric-figure version	interesting-figure version
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Selective attention	typical > ADHD = dyslexia	typical = dyslexia > ADHD
Sustained attention	typical = dyslexia > ADHD	typical = dyslexia > ADHD

*Note.* N = 30 for all groups

The results above show that interesting figures were beneficial for both ADHD and dyslexic children, but efficiency of interesting figures was not distinct for typical developing children. This might be due to the original attentional states. Because ADHD or dyslexic children possessed attentional problems, it was not difficult to significantly improve their attentional performance if they obtained something that attracted them. In contrast, typical developing children did not have any problems with attentional states, therefore, it was not easy to significantly increase their attentional performance.

Children with dyslexia had significant attentional problems in selective attention (Bender, 2004; Bowen & Hynd, 1988; Hallahan, 1989; Johnson, 1981; Ricards et al., 1990; Zentall, 1993), which meant that teachers might encounter trouble gaining the attention of dyslexic children. As indicated by the above results, efficiency of interesting figures was significant for the selective attention of dyslexic children (Cohen's  $d = 4.34$ ). Commission errors of dyslexic children were significantly more than typical developing children when presenting geometric figures, but they performed similarly in commission errors when interesting figures were presented. In other words, this method was useful to gain the attention of dyslexic children in the classroom.

The present study uncovers several interesting findings, such as interesting figures actually affected the attentional performance of someone with ADHD or dyslexia, but did not enhance the attentional performance of typical developing children. The general belief of teachers and parents is if you want to catch children's attention, use

something they like. However, in the present study, using interesting figures did not obtain great effect in the attentional performance of all children. This might be due to several reasons, such as the interesting-figure version in the present study was only a two-dimensional object on a screen, which was replaced by small icons. Using geometric-figure version and interesting-figure version to examine the effect of interesting figures in children's attentional performance would move closer to reality, but would lead to some experimental bias and disturbed factors in the experiment. Therefore, it should be considered in the future.

Encountering the attentional problems of ADHD children in the classroom has been unavoidable due to their deficiencies in both sustained attention and selective attention (Barkley, 1997; Castellanos & Tannock, 2002; Krause et al., 2003; Robertson et al., 1997; van den Bergh et al., 2006). However, in the present study, interesting figures did not show significant efficiency for both sustained and selective attention. For sustained attention, the effect of interesting figures was large (Cohen's  $d = 4.17$ ), but it was not as significant for selective attention (Cohen's  $d = 0.68$ ). The omission errors showed similar performance in ADHD children selecting interesting figures, but their commission errors were significantly more than that of normal and dyslexic children in presenting interesting figures.

Heterogeneity of children with ADHD is the possible reason for this issue. Some studies do not support the deficit of selective attention of children with ADHD (Barkley, DuPaul, & McMurray, 1990; Manly et al., 2001; Swaab-Barneveld et al., 2000; van der Meere et al., 2006). Therefore, the participants' condition with select bias that leads to these results should be controlled. In other words, it will be necessary to select samples more carefully in particular attentional performance (in the present study, the author selected samples using scores of the whole "Multidimensional Attention Test") when researches want to imitate the present study

in the future.

In contrast, dyslexic children's problems in the classroom did not been thought as an attention deficit. However, in the present study, interesting figures did show significant efficiency for selective attention. For selective attention, the effect of interesting figures was large (Cohen's  $d = 4.34$ ), but it was not as significant for sustained attention (Cohen's  $d = 0.60$ ). The commission errors showed similar performance in dyslexic children selecting interesting figures, but their omission errors were significantly more than that of normal and ADHD children in presenting interesting figures. This result consisted with the conclusion of Wang et al. (2010) which indicated that selective attention was dyslexic children's major attentional problem.

The results of the present study offered some suggestions about researching and teaching. For researching, the sustained problem of children with ADHD was their attentional problem, and the interesting figures provided a significant increase in their sustained attention. However, it is still not clear how geometric figures and interesting figures affect the neuro-physiological mechanism, and future studies could investigate this topic to make it more precise and clear. As previously mentioned, participants should be sampled more carefully in all attentional dimensions, not merely on the whole score of the attentional test. Results of the present study yield some impressions for teaching children with dyslexia and ADHD, such as it is easier to improve the selective performance of dyslexic children and the sustained attentional performance of ADHD children than previously believed. However, as authors mentioned above, the relevant evidence was still not enough to suggest extending directly to practice. Therefore, the present study was a pilot study, and it was necessary to study this issue by bigger sample size and more structure design in the future to examine it more deeply.



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