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Review of the Studies of ADHD Factor Structure reflected in DSM

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《 Abstract 》

The DSM-IV-TR is the most commonly used manual in the United States to identify students with ADHD. The DSM-IV-TR used in this study contains 18 ADHD criteria for children's problematic behaviors manifested in inattention and hyperactivity-impulsivity. Although DSM-IV-TR criteria have been used in research on ADHD with Korean school-age children, psychometric characteristics of ADHD criteria described in the DSM-IV-TR have not been examined. This missing information is imperative for quality research.

In this context, factor structures of ADHD need to be explained under theoretical assumptions, and it has to be examined educational context of various national situations. Therefore the purpose of this study was to review various researches on ADHD factor structure and to identify whether the current version of the DSM-IV-TR, which consists of two dimensions of inattention and hyperactivity-impulsivity, was appropriate for describing the psychological and behavioral problems of ADHD children of other countries.

Recently, some studies have been using confirmatory factor analysis to determine the factor structures of ADHD based on DSM versions. And the discussions and suggestions on ADHD factor structure and future studies was provided.

Key Words : Attention Deficit Hyperactivity Disorder (ADHD), the Diagnostic and Statistical Manual of Mental Disorders-IV-Text Revision (DSM-IV-TR), exploratory factor analysis, confirmatory factor analysis

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Ⅰ. Introduction

Attention-deficit/hyperactivity disorder(ADHD), characterized by inattention, hyperactivity, and impulsivity(American Psychiatric Association, 1994), is the most prevalent childhood neuropsychiatric disorder (Fantuzzo et al., 2001), affecting 5.29% of school-age children worldwide (Polanczyk, de lima, Horta, Biderman, & Rohde, 2007).

To understand the psychological and pathological nature of ADHD, general descriptions regarding ADHD and theories of ADHD has been presented. Due to various theoretical perspectives adopted by researchers in their research of ADHD, conceptual and clinical definition of ADHD has been changing constantly. A brief review on the changes of the ADHD concept will help us to understand the revolution of the theories of ADHD. One question centered in the evolution of the concept of ADHD is the factorial structure of the ADHD syndromes published in the DSM(Diagnosis and Statistics Manual) for diagnosis. Historically, one-, two-, and three- factor structures have been proposed and examined, and the results of the studies investigating the factorial structure of ADHD have not been conclusive or consistent.

Different organizations of ADHD can be found in each of the last three revisions of the DSM of the American Psychiatric Association. Beginning with the third edition (DSM-III American Psychiatric Association, 1980), ADHD was theorized to include three factors: inattention, hyperactivity, and impulsivity. Later, the factors were believed to be so interrelated that the revised third edition (DSM-III-R American Psychiatric Association, 1987) collapsed ADHD to a single dimension. The current revision, the fourth edition (DSM-IV American Psychiatric Association, 1994), portrays ADHD as containing two dimensions: Inattention and Hyperactivity-Impulsivity.

To make the issue more complicated, cross-cultural comparisons of the factorial structure of ADHD produced findings supportive for different models. A discussion on the studies and their inconsistent findings is needed to understand the structure and nature of ADHD. The evolution of the research on the factorial structure of ADHD was not only conceptually but also methodologically. In early research on the factorial structure of the

ADHD, the Exploratory Factor Analysis (EFA) was the major tool for the investigation.

With the newly developed technology, the factor structures of ADHD have been examined by using Confirmatory Factor Analysis (CFA) in recent years. To understand the development of methodology utilized in the research, some studies which examined the factorial structure of ADHD with CFA will be reviewed.

For the reference, there are the differences between EFA and CFA as followings. EFA is a statistical technique applied to a single set of variables where the researcher is interested in discovering which variables in the set form coherent subsets that are relatively independent of one another (Tabachnick & Fidell, 1996, p. 635). CFA is concerned with parameter estimation and tests of hypotheses regarding, for example, the number of factors underlying the relations among a set of indicators (Pedhazur & Schmelkin, 1991, p. 67). CFA compares alternative, theoretically plausible models to determine which model best represents the interrelationships among the items (Pillow, Pelham, Hoza, Molina, & Stultz, 1998).

In Korea, there are some researches exploring various intervention programs for children with ADHD (Yeo, 2007; Yeo, Lee, & Lee, 2007) and their parents (Kang, 2007; Lee, 2009; Woo, 2007), and the nature of ADHD such as executive functional characteristics (Song, 2009) and inhibition or working memory (Lee, 2009). However, there are no researches investigating the construct of ADHD like factor structures of ADHD. In other words, there are not researches which factor structures of ADHD based on DSM versions would be the best fit to Korean students. As a result, the researcher examined foreign studies regarding the factor structures of ADHD in advance.

For this, the databases such as PsychoInfo, Medline, and Eric and so on representing the areas of psychology, medical science, and education were searched by using the key-words of "ADHD and factor structure, ADHD and exploratory, ADHD and confirmatory" and etc.

The two dimensional model will be compared to three dimensions: inattention, hyperactivity, and impulsivity; based on the DSM-Ⅲ and one dimension, attention deficit hyperactivity disorder, based on DSM-Ⅲ-R. Therefore, this study consists of several kinds of literature review on the

factor structure of ADHD with EFA or CFA as research methodology. In the following, studies examining the factor structure of ADHD would be reviewed, even though these studies did not consider theoretical foundation much.

Ⅱ. The Factor Structure of ADHD

Studies investigating the factor structure of ADHD based on DSM criteria have been conducted internationally in both Western Countries and Eastern Countries. However, the majority of studies have taken place in the U.S. Other western researchers from Australia, Brazil, and Germany have sought to identify whether the factor structures of ADHD in DSM criteria can acquire cross-cultural congruency. Additionally, researchers from two Eastern countries, Taiwan and Japan, also contributed to examining the factor structure of ADHD utilizing DSM criteria. Most researchers exploring the issue have used exploratory factor analysis to reveal their outcomes. Recently, some scholars have begun to use confirmatory factor analysis instead of exploratory factor analysis.

Studies exploring the factor structures of ADHD in DSM versions have been done in both Western countries and Eastern countries, although Western interest in this issue has exceeded that in the East. Across countries, researchers in the U.S. have more often explored the factor structures of teacher ratings of ADHD symptoms than those in other countries have (Bauermeister et al., 1992, 1995; DuPaul, 1991; Healey et al., 1993; Hudziak et al., 1998; Lahey et al., 1988; Sherman, Iacono, & Mcgue, 1997; Pelham, Gnagy, Greenslade, & Milich, 1992; Wolraich, Hannah, Pinnock, Baumgaertel, & Brown, 1996).

In other Western countries such as Australia, Brazil, and Germany (Baumgaertel et al., 1995; Brito et al., 1995; Gomez at al., 1999) much research has been conducted as well. In addition, researchers in two Eastern countries, Taiwan and Japan (Kanbayashi et al., 1994; Yang et al., 2000) have examined the factor structures of DSM versions to screen for

ADHD. Those studies including both Eastern and Western countries used exploratory factor analysis to determine the factor structures of ADHD described in DSM versions. Recently, some studies have been using confirmatory factor analysis to determine the factor structures of ADHD based on DSM versions (e.g. Burns, Boe, Walsh, Sommers-Flanagan, & Teegarden, 2001; Dupaul et al., 1997; Dupaul et al., 1998; Konold & Glutting, 2008; Molina, Smith, & Pelham, 2001; Pillow et al., 1998; Proctor & Prevatt, 2009; Span et al., 2002). The aforementioned studies will be examined in detail in the following section.

1. The Factor Structure of ADHD in the U.S. Using Exploratory Factor Analysis

Most of the American studies supported a two-factor model, Inattention and Hyperactivity-Impulsivity, currently supported by the DSM-IV-TR. Lahey et al.(1988) examined the dimensions of DSM-III-R ADHD criteria from teachers' ratings of both nonreferred children and clinic-referred children. They argued that the DSM-III-R unidimensional conception of ADHD, based on the assumption that inattention, impulsivity, and hyperactivity are unitary aspects of the same factor, is not appropriate for screening ADHD because they found evidence of two factors, inattention-disorganization and motor hyperactivity-impulsivity factors.

The factor structures of ADHD were not different in clinical and nonclinical populations, even though the order of extraction of the factors was different in the two samples. The two different populations showed evidence of the same two-factor: a) inattention-disorganization; and b) motor hyperactivity-impulsivity. As a result, Lehey et al. (1988) revealed that both the DSM-III-R unidimensional definition(ADHD) and the DSM-III three-dimensional definition (inattention, hyperactivity, and impulsivity) were not appropriate for defining ADHD.

DuPaul(1991) examined the factor structures of ADHD from children aged 6 to 12 years in a large community-based sample. DuPaul(1991) collected the information from two sources, parents and teachers. The findings of the two different reports from parents and teachers were

similar. DuPaul(1991) found support for a two-factor structure including inattention-hyperactivity and impulsivity-hyperactivity. To determine the internal consistency of the ADHD Rating Scale based on DSM-III-R and its subscale, coefficient alphas were calculated. For parent ratings, Cronbach's alpha coefficients were .94 for the ADHD total score, .93 for inattention-hyperactivity, and .92 for impulsivity-hyperactivity. For teacher ratings, the values of alpha were .96 in ADHD total score, .95 for inattention-hyperactivity, and .94 for impulsivity-hyperactivity.

The internal consistency of the ADHD Rating Scale was excellent from both informants. DuPaul(1991) also checked test-retest reliability; he obtained the data at 2-week intervals in teacher ratings and 4-week intervals in parent ratings. The Pearson product-moment correlation coefficients used to analyze the test-retest reliability showed as follows: ADHD total score, .94; inattention-hyperactivity, .94; and impulsivity-hyperactivity, .90. Similar levels of stability were also found from teacher ratings. As a result, DuPaul's (1991) study showed that parent and teacher ratings of ADHD symptoms were internally consistent and highly stable over time. Inter-rater agreement was analyzed utilizing the Pearson product-moment correlation coefficients. He reported moderately high agreement between parent and teacher. He also explored criterion validity and found a strong correlation between the ADHD Rating Scale and ACTRS scores(Abbreviated Conners Teacher Rating Scale) from both teacher and parent ratings.

Healey et al. (1993) also examined 85 non-referred children ranging in age from 6 to 12 years. Similar to Lahey et al. (1988), Healey et al. (1993) found that the evidence supported the two factors of hyperactivity-impulsivity and inattention-disorganization. It seemed that items describing symptoms of inattention and disorganization came to be one category; inattention, in the current DSM-IV-TR. Therefore, their findings support the DSM-IV-TR in that they suggest that the characteristics of inattention are different from hyperactivity-impulsivity. In other words, their findings imply that when diagnosing ADHD, we need to differentiate inattention from hyperactivity- impulsivity. Nonetheless, Healey et al. (1993) their research was a small sample size and as a result, it needs to be viewed with caution to help draw more accurate conclusions from their study.

Pelham et al. (1992) showed the two factors' appropriateness, in their factor analysis of disruptive behavior disorders including ADHD, Oppositional Defiant Disorder (ODD), and Conduct Disorder (CD). Pelham et al. (1992) collected teacher ratings of DSM-III-R symptoms for disruptive behavior disorders, and analyzed the factor structures of it. The result showed three factors: one reflecting ODD and several CD symptoms, one reflecting ADHD symptoms of inattention, and one made up of ADHD impulsivity/overactive symptoms. Even though the study of Pelham et al. (1992) did not examine ADHD symptoms separately from the other behavior symptoms, the result of the facture structures of the disruptive behavior disorders support the DSM-IV-TR subtypes of ADHD. The subjects of their study were 931 boys between the ages of 5 and 14 attending regular classrooms and their regular classroom teachers rated them. The sample was gathered from educational professionals who responded to an article about ADHD. In other words, participants of the study were volunteers. The disruptive rating scale was based on DSM-III-R. Readers of this study might doubt the result because of two reasons. First, Pelham et al. (1992) included kindergarten age, which might be applied different diagnostic standard compared to elementary school children. Barkley (1997b) argued that DSM criteria might not be an appropriate tool for diagnosing ADHD in earlier age like kindergarten grade, or adolescents and adults, considering that ADHD is seen developmental disorder. Therefore, items reflecting inattention is unlikely to prove very sensitive to disorder with preschool age children from DSM criteria (Barkley, 1997b). It might be also difficult to observe behavioral problems like CD in young children. Second, the sampling is based on volunteer. As a result, the findings of Pelham et al. (1992) might be different from those of studies based on random sampling due to volunteer sampling. The volunteers in research might have different characteristics compared to subjects gathered from random sampling, thus their difference might impact on their evaluation to their students.

Most of the later American studies exploring factor structures of ADHD have supported a bidimensional conceptualization of ADHD consisting of two factors, (e.g., Bauermeister et al., 1995; Hudziak et al., 1998; Sherman et al., 1997; Wolraich et al., 1996). Bauermeister et al. (1995) obtained data in a community-based sample including teachers of children aged 4 through

16 years in Puerto Rico. The factor analysis of the data supported a bidimensional conceptualization of ADHD consisting of two subtypes, inattention, and hyperactivity-impulsivity.

Wolraich et al. (1996) examined the factor structures of all DSM-III-R and DSM-IV-TR symptoms for disruptive behavior disorders. Four symptoms of the disruptive behavior disorder, seven conduct disorder symptoms among 13 conduct disorder items were excluded, and replaced with seven items of anxiety or depression. Wolraich et al. (1996) got the information from teachers rating their kindergarten to fifth grade students on the aforementioned disruptive behavior disorders. They identified five factors: Oppositional/defiance-conduct, inattention, hyperactivity/impulsivity, anxiety/depression, and stealing-truancy. Like Pelham et al. (1992), Wolraich et al. (1996) revealed the appropriateness for the two-factor model based on DSM-IV-TR in combination with other comorbid symptoms rather than examining only ADHD symptoms.

Sherman et al. (1997) gathered information from teacher ratings and maternal structured interview reports of 576 twin boys, aged 11 and 12. Sherman et al. (1997) used DSM-III and DSM-III-R criteria for ADHD. Factor analysis of these measures supported the two-model dimension, inattention and impulsivity-hyperactivity of the DSM-IV-TR. Twin study methodology provides estimates of habitability, the amount of variance accounted for by genetic factors as well as for estimates for variance of shared and non-shared environmental effects. This study conducted univariate model-fitting analyses with LISREL to further examine evidence for genetic influences of subtypes of ADHD. Sherman et al. (1997) study supported a substantial contribution of genetic factors in the expression of inattention and impulsivity-hyperactivity and small contribution of common and unique environmental effects. Additionally, they suggested that to obtain reports from more than one informant source due to rater bias operated, particularly in maternal reports.

Hudziak et al. (1998) attempted to validate the current DSM-IV-TR criteria for ADHD in adolescent female twins. Hudziak et al. (1998) collected the data from the adolescent female twins' parents by telephone. Similar to the findings for male twins of Sherman et al. (1997), Hudziak et al. (1998) found that factor analysis of ADHD symptoms could be best

described as two factors, inattention, and hyperactivity-impulsivity.

2. The Factor Structure of ADHD in Other Countries Using EFA

The scholars of some other Western countries (Baumgaertel et al., 1995; Brito et al., 1995; Gomez et al., 1999; Rohde et al., 2001) also evaluated the factor structures of ADHD described in the DSM. Baumgaertel et al. (1995) compared diagnostic criteria for ADHD in a German elementary school sample by using DSM-IV-TR, DSM-III-R, and DSM-III criteria. This study explored the best fit of factor structures of the combined type of ADHD with disruptive behavior disorders such as conduct disorder and oppositional defiant disorder. Baumgaertel et al. (1995) found the four factor structures: inattention, hyperactivity-impulsivity, oppositional behavior, and conduct disorder. That is to say, in ADHD criteria, they found support for the two dimensional models of DSM-IV-TR when evaluated with combined types of ADHD and other behavior disorders. Baumgaertel et al. (1995) obtained information from 1,077 subjects, which is an adequate sample to examine statistical analysis from teachers' reports. They used rating scales including ADHD, ODD, CD criteria based on the DSM-III-R items, and ADHD and ODD criteria based on DSM-IV items. They chose volunteer teachers to complete the questionnaires. At least one teacher from each grade level from1 through 4 and from each school in five rural and five urban public schools participated in this study. It may not be a representative sample, because participants were collected based on volunteers.

Brito et al. (1998) obtained the data of Brazilian children from teachers' observations. They developed a teacher scale based on DSM-III-R criteria for ADHD to assess behavioral problems of children with ADHD in Brazil. Brito et al. (1998) also supported the two-factor model of ADHD described in DSM-IV. They collected 2,082 participants with a mean age of 11.2 years who were attending a public school in the greater Rio de Janerio, Brazil to complete the study. They collected information from only one school presumed representative of the population of public school children from Rio de Janerio. They believed the chosen school was the only normal school in the area. Therefore the researcher did not feel that this was not

a good representation of this population. They (Brito et al., 1998) did not consider the independence of observers because teachers surveyed the class as a whole, rather than one or two students from each class. They did not give detail information about participants for each grade; for instance how many subjects from each grade participated in the study. As a result, it is difficult to evaluate the samples as representative of the population of the Rio de Janerio, in Brazil. Brito et al.(1998) made their study more reliable by applying test-retest reliability. Test-retest reliability for each item of the ADHD scale based on DSM-III-R ranged from .56 to .70.

Rohde et al. (2001) evaluated the validity of DSM-IV for the diagnosis of ADHD in a school sample of young Brazilian adolescents. Rohde et al. (2001) found support for the bidimensional construct proposed by DSM-IV-TR criteria for the diagnosis of ADHD. All the 18 ADHD items based on the DSM-IV were administered to 1,013 students from 12 to 14 years old at 64 state schools and trained research assistant collected the data. 64 regular schools were decided through a proportional cluster random sampling based on school size from the 246 state schools. The students were randomly selected from a list of all students from 12 to 14 years old. The sample size and sampling method in the study were appropriate for validation of their findings.

Researchers from Eastern countries, like Taiwan and Japan, explored the factor structure of ADHD described in the DSM-IV and DSM-III-R respectively. In a Taiwan study, Yang et al. (2000) tried to compare factor structures from Taiwanese teachers' ratings of ADHD with factor structures reported in research using school-based American participants. Participants of the study were 121 homeroom teachers from six public elementary schools in Taipei County, Taiwan. Teachers rated two boys and two girls randomly selected by a stratified sampling technique. Yang et al. (2000) supported the cross-cultural congruency of behavioral symptoms of ADHD by finding the two-factor structure: a) inattention; and b) hyperactivity -impulsivity, of DSM-IV. To identify factor structures of ADHD in Taiwanese students, Yang et al. (2000) used diagnostic definitions of ADHD as described in the DSM-III, DSM-IV, and ICD-10. The Taiwan study was generally well designed and executed because the sample size was adequate. This

study included 454(boys=231, girls=223) and the participants were randomly selected.

However, in a Japanese study (Kanbayashi et al., 1994), three dimensions: a) inattention; b) hyperactivity; and c) excessive verbal activities, were found. The study was based on two surveys. The participants of survey one were parents of children enrolled in grades one through four in elementary schools in a metropolitan city in Japan. Participants of survey two were parents of children enrolled in preschool, fifth grade and sixth grade. This study had a few methodological flaws. For example, first, the total response rate of participants in the study was 47.8%, but the researchers did not explain the characteristics of non-respondents. As a result, it is difficult to make generalizations about whether respondents of this study are representative of the target population. The researchers failed to show that the two groups of respondents and non-respondents were not different in their characteristics using the demographic information. Therefore, external validity, the extent to which the results of an experiment can be generalized from the sample to the population, was suspicious in this study. Researchers only mentioned that there was no significant difference in the response rate to age or gender.

Second, in sampling technique, the researchers didn't describe exactly how researchers got the participants. They mentioned that children of each different age were recruited from residential records kept in the ward office, but they did not explain how they chose the participants among the records. Readers could not determine how the researchers chose the appropriate age groups of children or how they chose some participants according to certain rules. Third, this study did not show the demographic information of the participants. Consequently, we cannot consider whether demographic factors like students' socioeconomic status (SES) had an impact on ADHD symptoms or not.

Fourth, the measure did not show high levels of validity, even though the researchers introduced the word validity. The validity looked like inter-rater reliability, because the validity test was administered by the way that parents and clinicians rated 74 clinical cases and found a significant relation between the two groups. Validity is more important in quantitative research, and the researchers should have shown more validity

evidences. Nonetheless, in contrast to studies of most of the Western countries, it is note worthy that the factor structure of the Japanese study was different. For instance, inattention was the main factor in contrast to other studies. Ignoring some methodological flaws in the Japanese study, one plausible explanation of the different results between the two countries might be different reporting sources (teachers vs. parents).

3. Confirmatory Factor Analysis Examining ADHD

In contrast to studies using exploratory factor analysis to analyze their data, some researchers used confirmatory factor analysis to determine which model is the best fit for the combination of ADHD with other disorders, such as with ODD or CD (Burns et al., 2001; Molina, Smith, & Pelham, 2001; Pillow et al., 1998; Gomez, Burns, Walsh & Hafetz, 2005). Other authors also examined ADHD in isolation (e.g., Kanbayashi et al., 1994; Sherman et al., 1997; Span et al., 2002; Yang et al., 2000). Most of the confirmatory factor models have been explored in the U.S. (e.g., Burns et al., 2001; DuPaul, Anastopoulos, McGoey, Power, Reid & Ikeda, 1997; DuPaul, Anastopoulos, Power, Reid, Ikeda & McGoey, 1998; Pillow et al., 1998; Molina et al., 2001; Span et al., 2002) except for two studies, one involving data collected in Australia (Gomez et al., 1999), and the other using data collected in the US and Canada (Beiser et al., 2000).

DuPaul et al. (1997) obtained behavioral rating scales from teachers to identify ADHD. DuPaul et al. (1997) examined kindergarten through 12^{th} grade children and adolescents. They analyzed their data by using both exploratory factor analysis and confirmatory factor analysis. They found that two-factor model, inattention, and hyperactivity-impulsivity, was adequate representative model to the observed data compared to one-factor model. The one-factor model was that all items were constrained to load on a single factor, ADHD. They examined the fit indices of RMSEA. They found that RMSEA was a good fit for both models. However, the x^2 difference test showed that the two-factor model significantly increased in fit over the one-factor model. DuPaul et al. (1998) reported parent ratings of ADHD symptoms, whereas they presented teacher ratings of them in 1997.

They found similar results as the study of 1997. They still supported the two-factor model, inattention and hyperactivity-impulsivity, from parent reports.

Pillow et al. (1998) used confirmatory factor analysis to examine ADHD symptoms and other childhood disruptive behaviors. Pillow et al. (1998) collected the data from clinic-referred boys between the ages of 5 and 15. Pillow et al. (1998) compared among three DSM versions, the DSM-III-R one-factor model, DSM-IV-TR two-factor model, and DSM-III three-factor model respectively. Next, they compared the combined models with these three ADHD models and other childhood disruptive behaviors such as conduct disorder and oppositional defiant disorder. Pillow et al. (1998) found that the three-factor ADHD model based on the DSM-III was the best fit when the ADHD symptoms were examined in isolation, the two-factor model of DSM-IV-TR was the best fit when ADHD and ODD/CD symptoms were examined together as part of a comprehensive model of disruptive behavior disorder. Pillow et al. (1998) made comprehensive models of disruptive behavior disorder to understand the role of impulsivity in ADHD and/or ODD.

Pillow et al. (1998) reported the values of alphas as the evidence of internal consistency in their study. Alphas for inattention were .80, .69 in impulsivity, and .82 in hyperactivity. DSM-IV-TR (American Psychiatric Association, 1994) explains that ODD must be distinguished from the characteristics, including inattention and impulsivity, resulting from ADHD. Much of the impairment apparently tied to ADHD was actually linked to comorbid ODD and CD (Lahey, Pelham, Stein and Loney et al., 1998). Hinshaw (1987) and Lahey et al. (1988) suggested, "The two dimensions of ADHD were empirically distinct from ODD and CD, providing support for the construct validity of the ADHD disorder" (as cited in Molina et al., 2001). Pillow et al.'s (1998) study showed construct validity supported by the fact that ADHD and ODD are distinct from each other.

Beiser et al. (2000) explored the structure of ADHD with Native American and non-native American elementary school children by using DSM-III-R and DSM-IV-TR symptom categorizations of ADHD. This study took place at four geographically different sites, two in the U.S. and two in Canada. They also attempted to evaluate the cross-cultural

appropriateness for the best-fit model of ADHD. Beiser et al. (2000) found from teacher and parent ratings, a two-factor model corresponding to the DSM-IV-TR conceptualization of two dimensions providing better fit than the one-factor model for both groups. For student self-ratings, the two-factor model did not show better fit than the one-factor model. They examined the fit indices such as the Adjusted Goodness-of-Fit Index (AGFI; Joreskog & Sorbom, 1988), the CFI, and the RMSEA.

Burns et al. (2001), using confirmatory factor analysis, considered ADHD and ODD symptoms together and did not consider ADHD independently. To evaluate these models, from maternal ratings information regarding ADHD and ODD symptoms of clinic-referred children was obtained. Burns et al. (2001) examined the five models such as Model 1, a single factor model; Model 2, an ADHD and ODD two factor model; Model 3a, an inattention (INA), hyperactivity/impulsivity (HYP/IMP), and ODD three-factor model; Model 3b, an INA, HYP/IMP, and ODD three-factor model where the three IMP symptoms cross-load on the ODD factor; Model 4, and INA, HYP, IMP, and ODD four factor model. The results showed that the three-factor model, inattention, hyperactivity/impulsivity, and ODD, was the best fit among five models. In other words, even though ADHD was not examined in isolation, when ADHD and ODD were examined together, the result supported that the representative types of ADHD were inattention and hyperactivity-impulsivity. This study provided the construct validity of ADHD by showing that the two dimensions of ADHD, inattention and hyperactivity/impulsivity, were separate characteristics from ODD; and ADHD and ODD were associated with each other.

Such as the Burns et al. (2001) study, Molina et al. (2001) examined similar research questions. Molina et al. (2001) also explored ADHD and ODD together. The participants and sources of data reported in the Molina et al. (2001) study were different from the Burns et al. (2001) study. That is to say, Molina et al. (2001) obtained data regarding adolescents from teacher ratings, whereas Burns et al. (2001) focused on children and obtained their data from maternal ratings. Molina et al. (2001) also supported the two-dimensional conceptualization of ADHD described in the DSM-IV-TR when examined together with ODD.

Burns et al. (2001) evaluated internal consistency of the diagnostic definition of ADHD based on the DSM-IV. According to them, alpha for inattention was .91, for hyperactivity/impulsivity, .92, for hyperactivity, .86, and for impulsivity, .83. We can see the internal consistency in the subcategories in the DSM-IV were, on the whole, good and excellent. It seems that DSM-IV is associated with reliable scores of ADHD items. Burns et al. (2001) evidenced the construct validity of ADHD by revealing that characteristics of ADHD were distinct from ODD but they were related to each other.

Span et al. (2002) examined the factor structure of ADHD in adult non-clinical samples by using confirmatory factor analysis. Span et al. (2002) examined the factor structure of 18 items of ADHD based on the DSM-IV criteria. They compared four models: The one-factor model proposed by DSM-III-R, the two-factor model proposed by the DSM-IV, the three-factor model proposed by the DSM-III, and the null model proposed that each of the 18 items would measure its own, independent, underlying factor. Span et al. (2002) compared the x^2 difference among the nested four models, and they found that the three-factor model was the best fit to the data. They examined ratio of chi-square to degrees of freedom (RATIO), the Parsimonious Fit Index (PFI), and Akaike's Information Criterion (AIC). "RATIO, PFI, and AIC illustrate the magnitude of the difference between the model and the data with respect to the number of degrees of freedom" (Span et al., 2002, p. 131). In contrast to the aforementioned studies, this study focused on adults. They found that the 3-factor model (inattention, hyperactivity, and impulsivity) fit the data more significantly than the other two models.

For the most part, the aforementioned studies have been done in the U.S.A. The Gomez et al. (1999) study and the Beiser et al. (2000) study are the exceptions. The Gomez et al. (1999) study was done in Australia. Gomez et al. (1999) study was similar to Span et al. (2002) in that they also compared the three models of ADHD like Span et al. (2002). However, Gomez et al. (1999) examined primary school children with ADHD from both parent and teacher ratings. They suggested that both the two-and three-factor models were good, but the three-factor model (inattention, hyperactivity, and impulsivity) was only slightly better than the two-factor

model (inattention, and hyperactivity-impulsivity).

Gomez et al. (1999) reported the validity score like concurrent validity and reliability scores such as alphas and test-retest scores in their study. Cronbach's alpha coefficient scores for parent ratings were .92 for inattention, .90 for hyperactivity/impulsivity. The teacher ratings for the same were .95 for inattention and .94 for hyperactivity/impulsivity. The internal consistency was rated higher from the teachers' reports than that of the parents' reports. Second, they reported that the 3 month interval test-retest reliability for parent ratings of inattention and hyperactivity/impulsivity were .55 and .55 respectively, whereas for teacher ratings they were .70 and .73 respectively. This test-retest reliability again affirmed that teachers' reports were more reliable across occasions. Third, as the concurrent validity, the correlation between ADHD rating scale in DSM-IV and ADHD items in the Abbreviated Conners Rating Scale for both parent (ACPRS) and teacher (ACTRS) were examined. They indicated that the correlations in parent ratings between inattentive items and hyperactivity /impulsivity items and ACPRS were .76 and .84 respectively. The correlation in teacher ratings between inattention items and hyperactivity/impulsivity items with the ACTRS were .77 and .86 respectively.

Ⅲ. Discussions and Suggestions

As explored before, many studies examining factor structures of ADHD were based on exploratory factor analysis. Even though currently several studies exploring factor structures of ADHD were based on confirmatory factor analysis, more studies using confirmatory factor analysis are needed. The studies using confirmatory factor analysis need to be developed using stronger theoretical foundations.

1. The Factor Structure of ADHD based on EFA

Most of the previously mentioned studies regarding factor structures of

ADHD collected the data from teachers (Bauermeister et al., 1995; Baumgaertel et al., 1995; Brito et al., 1998; DuPaul 1991; Pelham et al., 1992; Yang et al., 2000), but some studies report the data from parents (Bauermeister et al., 1995; DuPaul 1991; Kanbayashi et al., 1994).

For over 20 years before the DSM-IV-TR was presented in public, researchers and clinicians commonly accepted ADHD as consisting of three primary symptoms: a) poor sustained attention; b) impulsiveness; and c) hyperactivity (American Psychiatric Association, 1980, 1987; Barkley, 1981; Douglas, 1973, 1983, as cited in Barkley, 1997). The factor studies of ADHD administered in other countries suggest the cross-cultural validity to the diagnostic definition of ADHD based on DSM-IV-TR criteria. Most studies using this criteria support the two-dimensional subtypes. Most studies conducted in other countries, including Eastern and Western countries (outside of the U.S.) obtained their information from teacher's reports. The Japanese study only relied on parents' ratings. It is surprising that almost all of the international studies support the DSM-IV-TR criteria made in the U.S. excluding the Japanese study.

And among the aforementioned United States studies, most studies collected the information about their participants from teachers' reports, except for Hudziak et al. (1998) who obtained information from participants' parents. Three studies (Bauermeister et al., 1995; DuPaul, 1991; Sherman et al., 1997) gathered information from the two sources of both parents and teachers. Teacher observations are an essential source in screening ADHD when considering that ADHD symptoms are usually well developed by school age and are most clearly visible in the school and classroom environment compared to the less structured home environment (Baumgaertel et al., 1995). The age examined in the aforementioned studies was mainly elementary school children except for the Hudziak et al. (1998) study, which evaluated adolescents. Most studies described above examined the factor structures of ADHD independently except for the two studies (Pelham et al., 1995; Wolraich et al., 1996) that examined ADHD dimensions with other comorbid behavior disorders.

2. The Factor Structure of ADHD based on CFA

The studies that examined children with ADHD, generally revealed the support for that the two-factor model (inattention, hyperactivity-impulsivity). This two-factor model is the best fit except for the two studies, Span et al. (2002), and Gomez et al. (1999). Gomez et al. (1999, 2005) found support for the three-factor model based on information about primary school children. Similarly, Span et al. (2002) also found support for the three-factor model. This fits the data significantly better than one-and two-factor models from the data evaluated from University students' study. When ADHD was examined together with ODD, the two-factor model of ADHD (inattention, hyperactivity-impulsivity) was also the best fit. Further, even we might suspect that ADHD factors in a combined model with ADHD and ODD or CD could be different from ADHD alone. Among the aforementioned studies using CFA examining ADHD, the two studies (Beiser et al., 2000, DuPaul et al., 1997) compared only a one-factor model and a two-factor model excluding the three-factor model of ADHD. Therefore, based on the two studies, it is not clear which model fits best; the two or the three-factor model. The researchers might encounter limitations using multiple models in CFA, because they may fit the data equally well.

Among the aforementioned studies in the section of confirmatory factor analysis (Burns et al., 2001; Pillow et al., 1998) examining ADHD, found support for both the two-factor and the three-factor models and they were the best fit to the data. However, the three-factor revealed slightly higher scores in each fit index, NFI, TLI, and CFI in Pillow et al. (1998) study. Also, the three-factor of ADHD with ODD was slightly higher in CFI, RCFI, RSMR, and RMSEA in Burns et al. (2001) study. Nonetheless, Burns et al. (2001) concluded that the two-factor analysis was the best fit because of statistical reasons. For example, Burns et al. (2001) stated that hyperactivity and impulsivity had a higher correlation than the correlation between impulsivity and inattention, or hyperactivity and inattention. Pillow et al. (1998) explored the factor structure of ADHD separately from aggressive disorders including ODD and CD. They found different outcomes in two different cases. One, when the factor structure of ADHD was examined in isolation; the three-factor model was the best fit to the data

than the other two alternative models. Second, when the factor structure of ADHD was explored combined with ODD and CD, the two-factor model of ADHD showed the best fit to the data. Therefore, future studies need to explore closer the two different factor structures, ADHD only or ADHD and other disruptive behavior disorders. Without giving explanation about theoretical foundation about their factor models, the researchers did not seem very reasonable about their conclusion about the two-factor model as the best fit with the data. The conclusion based on statistical numbers need to be supported by theoretical foundation to have more accurate results.

3. The Factor Structure of ADHD

Most of the research designed to explore the dimensions of ADHD has been based on exploratory factor analysis methodology. However currently, a few studies have come to use a more advanced statistical method, confirmatory factor analysis (Beiser et al., 2000, Pillow et al., 1998; Burns et al., 2001), to identify the dimensions of ADHD. CFA allows researchers to decide which model is the best representative one to display the interrelationships among the items, comparing alternative plausible models (Pillow et al., 1998). "A key advantage of using CFA is that the correlations between the dimensions can be represented within the model while simultaneously forcing an explicitly defined simple factorial structure onto the data" (Pillow et al., 1998, p. 294-295). By using CFA to compare the one-factor model, *ADHD*, and three-factor model, *inattention, hyperactivity, and impulsivity* with the two-factor model, *inattention and hyperactivity-impulsivity*, we can see what is the best model in diagnosing ADHD.

Historically, ADHD has been renamed and redefined by the DSM versions. Finally, the current DSM-IV-TR has provided a two-factor model, inattention and hyperactivity-impulsivity, to diagnose ADHD. When the DSM-IV-TR was revealed for the first time, the two-factor model was controversial among scholars, especially because the combined hyperactivity-impulsivity had not been examined much through field study. Even though some scholars agree with the two-factor model of inattention and hyperactivity-impulsivity, (e.g., Bauermeister et al., 1992; Healey et al., 1993; Beiser et

al., 2000; Rohde et al., 2001), other scholars still argue that the three-factor model, defined as inattention, hyperactivity, and impulsivity, would be the best fit (e.g., Gomez et al., 1999; Span et al., 2002). Therefore, the model that best defines ADHD needs to be explored through more studies.

4. Future studies

The three characteristics representative of ADHD need to be studied regarding each factor independently. Especially, impulsivity needs to be investigated more because the present DSM-IV-TR has only three items relative to the importance of behavioral inhibition, assumed to be the main mechanism of ADHD.

Above all, theoretical considerations and development in ADHD studies need to be developed continuously. The hybrid neurological model of executive functions developed by Barkley (1997a, b) contributes to explain the nature of ADHD. The model is essential in the attempt to explain the nature of ADHD in a unifying system. However, the model needs to be investigated through future studies to be confirmed as a more sound theory, even though some areas related to the three executive areas, verbal working memory and nonverbal memory, and motivation, affect, and arousal regulation were explored by several neurological studies and still more fruitful studies. Another executive area such as reconstitution is still primitive. As a result, the behavioral inhibition and the four executive functions assumed to be linked to the behavioral inhibition need to be studied more deeply.

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DSM에 제시된 ADHD 요인구조 관련 연구 탐색

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<국문초록>

『정신장애의 진단 및 편람 제4개정판』(이하 DSM-IV-TR)은 미국에서 주의력결핍 과잉행동장애(이하 ADHD) 아동을 선별하기 위해 가장 흔히 사용되는 기준이다. DSM-IV-TR 진단기준은 부주의, 과잉행동-충동성과 같은 문제행동을 변별하기 위해 18개의 항목으로 이루어져있다. 한국에서 이 진단기준이 번역되어 사용되고 있지만 그에 대한 심리측정적 특성들은 국내에서 충분히 검토되지 않은 실정이다.

ADHD의 요인구조에 대한 연구는 이론적인 가설 내에서 연구되어야 하고, 각 국가의 상황을 고려하여 교육적 맥락에서 또한 검토되어야 한다. 따라서 탐색적 요인분석과 이론적 토대를 기반으로 하는 확증적 요인분석을 사용하여 요인을 분석한 다양한 연구를 통해, ADHD의 DSM-IV-TR 진단 항목에서 현재 사용되고 있는 두 가지 요인구조인 부주의 우세형, 과잉행동-충동성 우세형이 주의력결핍 과잉행동장애를 대표할 수 있는 범주인지를 검토해보았다. 여러 국가의 다양한 연구를 통해 최근에는 ADHD의 요인에 대해 탐색적 요인분석보다는 확증적 요인분석을 통해 연구하는 경향을 알 수 있었으며, 우리나라 ADHD 아동의 요인구조에 대해 논의점과 미래연구를 제안하였다.

주 제 어
: 주의력결핍 과잉행동장애(ADHD), 정신장애의 진단 및 편람 제4판(DSM-IV-R), 탐색적 요인분석, 확증적 요인분석

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