The Mixture Model of Executive Functions and Ordinary National Educational Score

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ABSTRACT

The purpose of this qualitative correlational study was to investigate and validate a mixture model of executive functions (EFs) and Ordinary National Educational Test (O-NET) score. The sample consisted of 235 adolescences in age of 12 to 15 years in Chon Buri, Thailand. The instruments were used to assess the performances which were Digit Span task, Trail Making Test, and O-NET record form. The results of adjust model imply that the data was consistent with the empirical evidence. Goodness of fit statistic were; chi-square = 12.520, df = 12, p = .405, GFI = .986, AGFI = .967, CFI = 1.000 SRMR = .0259, RMSEA = .014. The variables in the model established for 86.6 percent of the total variance in O-NET scores. EFs attributes influenced O-NET scores most.

Keywords: executive functions, adolescence, mixture model

INTRODUCTION

Executive functions (EFs) known as cognitive control. In 1975, the psychologist Michael Posner used the term "cognitive control" on the topic "Attention and cognitive control" in his book (Zillmer, Spiers, & Culbertson, 2007). EFs are an umbrella term used to describe the initiation behavior, decision making, and goal directed behavior (Miller & Cohen, 2001). It can enrich each person to transit from one task to another, to stop an impulsive act, and to sustain attention to task following directions. The EFs lead to increase cognitive flexibility in daily living, playing, and learning of their life. Having the EFs will help the children can be letting go of a specific interest and paying attention on more important activities (Zillmer et al, 2007). In the past, the influence of research study on executive functioning grew rapidly, a number of studies have described that EFs exist to have many the components. Hamilton et al. (2008) and Miyake et al. (2000) identified three key EFs: shifting (Shifting), information updating or monitoring (Updating), and inhibition of greatly influential responses (Inhibition). Many researches described that brain regions and functions about EFs depend on frontal lobe which is in the prefrontal cortex (PFC) that is about self-control, judgment, emotional regulation which developing restructured in ten years. For association areas also have temporal lobes control emotional maturity that is still developing after age 16. Corpus callosum also continue to grow that involve of intelligence, consciousness and self-awareness that relate to capacity of executive functioning into the full maturity in 20s. (Spano, S., 2003) in Therrien, K. J., 2009, Sharon, B., 2000). However, many researchers found that the adolescence is important change EFs process. Especially, there are many investigations of the

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structure of EFs from childhood to adolescence. This currently present structural equation model analyses showed that the structure of EFs changed in range 8-11 years old (Brydges, Reid, Fox, & Anderson, 2012, 2014).While executive functioning can be measured across lifespan using neuropsychology assessment. For example, a number of studies used the Trail Making Test (TMT; Tombaugh, 2004) have shown successfully provides information on visual search, scanning, mental flexibility, and executive functions. Furthermore, Digit Span (DS) were designed for working memory (Prencipe, Kesek, Cohen, Lamm, Lewis, & Zelazo, 2011). Other studies offered alternative assessment; the stoop task, Go/no Go, Letter-number sequencing, Wisconsin Card Sorting Task (WCST) that can identified the EFs. Moreover, executive functioning is related to academic outcomes in which described the individual differences in EFs that are related to literacy, writing, and science achievement (Bull, & Lee, 2014; Best, J Miller, & Naglieri, 2011; St. Clair-Thompson & Gathercole, 2006). Many studies report that the direct effects of EFs are strongly related for mathematics performance (Bull, & Lee, 2014; van der Ven, Kroesbergen, Boom, & Leseman, 2012).

Meanwhile, Thailand's educational system is divided into three levels that consisted of kindergarten, primary school, and secondary school. At the end of each year, each child must take a test for moving to the next level. Administration also is organized by National Institute of Educational Testing Service (NIETS) that conducts General Aptitude Test (GAT), Professional and Aptitude Test (PAT), Advanced National Educational Test (A-NET), and Ordinary National Educational Test (O-NET). Additionally, the Program for International Student Assessment (PISA) that measure the quality of literacy every three years. PISA also assesses mathematics, reading, and science in 15 year old students. Therefore, this present study used O-NET score that assess for grade 6, grade 9, and grade 12 students to evaluate their academic competency. O-NET composes of 8 major subject areas according to the national education curriculum such as Thai language, Mathematics, Science, Social science, Religion, and Culture, Health and Physical education, Art, Career and Technology, and English (http://www.niets.or.th/) Therefore, O-NET scores are used to assess knowledge achievement in each age. It is related to the children's brain abilities development.

Therefore, the focus of this study was to test four observed variable of executive functions (EFs) and three observed variable of Ordinary National Educational Test (O-NET) scores. In addition, this study used the resulting model of executive functioning to decisive the relationship between executive functioning and national education testing scores. Confirmatory Factor Analysis (CFA) and Structure Equation Model (SEM) were investigated to test between Digit Forward (DF), Digit Backward (DB), and Trail Making Test (TMT) part A,TMT part B and EFs in adolescence. The three major of subjects consist in English, Mathematics and Science was also investigated O-NET outcome. Furthermore, we explored to evaluate a specific hypothesis. Based upon previous theory and evidence it was hypothesized that capacity on EFs are able to lead up national education testing outcome in adolescence. (St Clair-Thompson & Gathercole, 2006; Miyake et al., 2000)

MATERIAL AND METHODS

Participants

A total of 235 adolescences (102 males and 133 females) participated in the study. The participants are enrolled of 12 to 15 years. They were 53participants in grade 7 (25 males and 28 females), 72 participants in grade 8 (28 males and 44 females), and 110 participants in grade 9 (49 males and 61 females). All participants were recruited from four lower-secondary schools that are situated in Chon Buri province, Thailand. This study used the convenience

sampling. The data were collected between January and March 2015. The researchers asked and evaluated each participant to spend at least 20-30 minutes.

Instrument

The research instrument composed of three parts. First, The Digit Span (DS) subtest composed of two types of assessment. Digit Forward (DF), which requires participants to repeat a sequence of digits number-for-number and Digit Backward (DB), which requires participants to repeat the digits in reverse order. The sequences ranging from two to nine digits that each sequence was presented by the research worker at a rate of one digit per second, after which participants were required to repeat the digit from memory. Two trials were administered for each sequence length; if participants were correct on either trial, then they advanced to the next sequence length, with the number of digits increasing by one. Scores were computed by counting the total number of sequences successfully remembered in each condition. DF and DB were analyzed as separate dependent variables. The total of score is 30 points (Jensen, & Figueroa, 1975; Anastopolous, Spisto, & Maher, 1994).

Second, the Trail Making Test (TMT) version tablet application consists of the TMT Part A and the TMT Part B. Both parts of the TMT consist of 25 circles distributed over the 9.7 inch screen tablet. In Part A, the circles are numbered 1-25, and the participants will be asked to touch the numbers in ascending order. In Part B, the circles include both numbers (1-13) and letters (A-L); the participants will have to touch the circles in ascending pattern, but with the added task of alternating between the numbers and letters (i.e., 1-A-2-B-3-C, etc.). For each part, there will be a practical trial consisting of eight circles. The TMT is determined by recording the time for the completion of each part (Tombaugh, 2004; Christidi et al., 2015).

Finally, the record form that consists of grade, gender, and O-NET scores. O-NET scores are recorded only English Mathematics, and Science when pass the elementary level. Individual information data is from National Institute of Educational Testing Service (NIETS) website.

Procedure

Participants were asked to answer the questionnaire in the record form. They were tested individually in four tasks which used to discriminate the EFs factor. The administration was in two sessions as follow. In the first session, the participants were settled in front of a tablet screen and comfortable position, and then they completed TMT part A and TMT part B. In the second session they completed DF and DB. In the both session, the researcher worker was seated at the table in other side and collected all data in the record form.

Statistical Analysis

Descriptive statistics are used to analysis and describe the basic element of the data in this study. In both CFA and SEM were used by LISREL 9.2student version.

RESULTS

The purpose of this analysis was to investigate whether the performance of adolescence on different the EFs reflected O-NET ability, to examine how any observed variables would contribute to executive functioning performance, to determine whether the three major of subjects would be represent to O-NET scores with adolescence**.** (St Clair-Thompson & Gathercole, 2006). To describe these goals in more details, these results are presented in three sections. First section, show descriptive statistics and correlations among all variables are described and discussed. Second section, show CFA of the EFs and O-NET scores. Finally

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section, a SEM analysis is explored, including consideration of the factors identified in the mixture model.

Table 1. Descriptive Statistics for the EFs Tasks and O-NET scores (N=235)

Variable	*Min*	*Max*	*Mean*	*SD*	*Skewness*	*Kurtosis*
			The EFs Tasks			
DF	3	16	11.23	2.52	0.00	-0.41
DB	2	14.9	4.76	2.16	1.66	3.47
TMT A	11.2	49.4	22.03	6.77	1.27	1.98
TMT B	23	267	65.03	30.12	2.19	9.03
			The O-NET Scores			
ENG	5	92.5	39.94	21.69	0.93	-0.30
MATH	5	98	49.26	23.23	0.32	-0.93
SCI	6	98	41.09	16.37	0.80	0.43

Note: DF= Digit Forward, DB=Digit Backward, TMT A=Trail Making A, TMT B=Trail Making B, ENG=English scores, MATH= Mathematics scores, SCI=Science scores

The descriptive statistics of measurement are summarized that the EFs tasks and O-NET scores are presented in Table 1. We clear the missing data and consider outliers since this can affect SEM results (Schumacker, & Lomax, 2004). All of the measures had relatively high skewness coefficients, and the kurtosis coefficients of TMT B rather peak. Correlations among the seven variables are presented in Table 2. All the patterns of correlations are significantly correlated (α= .01) between variables that positive range between .28 and .61.Negative range between -.44 and -.24. Both DF and DB scores were negatively related with TMT performance but were positively related with O-NET scores. TMT A and B performances were negatively related with O-NET scores. The most correlated between English scores and Mathematics scores (r = .61). The least correlated between DF scores and TMT B performance (r = -.24). This result can be studied and analyzed future because all observed variables had correlated.

Table 2. Correlations between measure of the EFs Tasks and O-NET scores (N=235)

	DF	*DB*	*TMT A*	*TMT B*	*ENG*	*MATH*	*SCI*
DF	1						
DB	.35**	1					
TMT A	-.32**	-.31**	1				
TMT B	-.24**	-.25**	.53**	1			
ENG	.33**	.48**	-.44**	-.42**	1		
MATH	.30**	.45**	-.38**	-.38**	.61**	1	
SCI	.28**	.32**	-.33**	-.31**	.60**	.55**	1

Note: DF= Digit Forward, DB=Digit Backward, TMT A=Trail Making A, TMT B=Trail Making B, ENG=English scores, MATH=Mathematics scores, SCI=Science scores

**Correlations significant at <.01.

The measurement model of executive functioning is evaluated through Confirmatory Factor Analysis (CFA). The one-factor model with four indicators loading on the factors as follows: DF, DB, TMT A, and TMT B. The initial test of the model result was not good because the root-mean-square error of approximation (RMSEA) greater than .05. Thus, we correlated the residuals of similar tasks (e.g., DF, DB). The correlation between the DF and DB tests were small and positive (.200), but not significant. This model was the best fit that was consistent with the previous studies. Chi-square = .030, df = 1, p-value = .867, GFI = 1.000, AGFI = .999, CFI = 1.000 SRMR = .0002, RMSEA = .000. The finding conforms to hypothesis which describes factor to interfere in the EFs in adolescence. The CFA was also used with O-NET scores. The three indicators (English, Mathematics, and Science scores) were determined; fit of a model was just-identified model. Chi-square = .000, df = 1, p-value = 1.000, RMSEA = .000 (See figure 1 and 2).

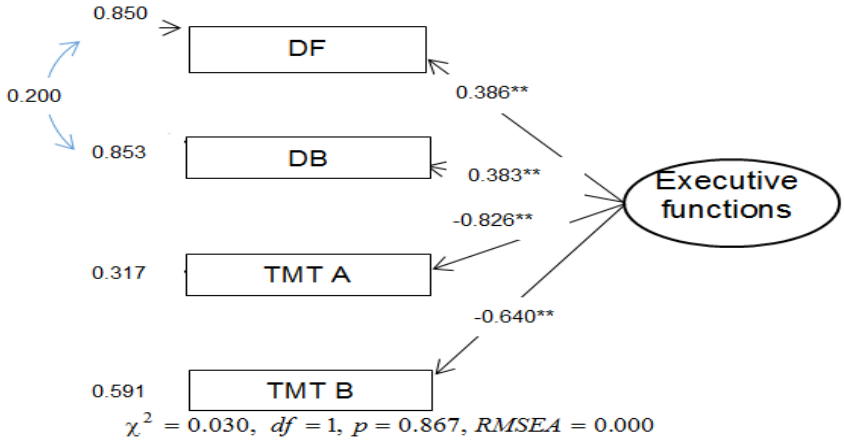

Figure 1. Confirmatory Factor Analysis of EFs tasks

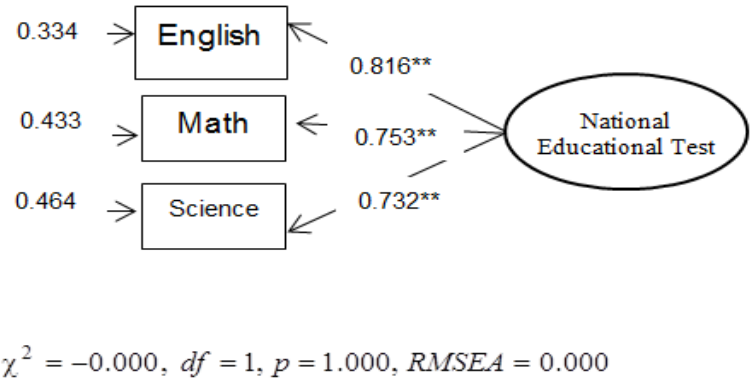

Figure 2. Confirmatory factor analysis of O-NET scores

This study was to examine the influence of EFs on national education testing using a Structural Equation Mixture Modeling (SEMM) analysis. This is hypothetical data set that concerns the EFs influence of the O-NET scores corresponded to the empirical evidence. Fit of the model was adequate Chi-square = 12.517, df = 12, p-value = .405, GFI = .986, AGFI = .967, CFI = .999 SRMR = .026, RMSEA = .014. Moreover, the EFs significantly influence

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O-NET scores (R^2=.866, α <.01). The observed variables of EFs had highly positive factors loading that were the DB and DF (.584 and .451 respectively). But TMT A and TMT B were highly negative factors loading, (-.555 and-.511 respectively). Additionally, the observed variables of O-NET scores had highly the factor loading that were English, Mathematics, and Science scores (.818, .763 and.704 respectively) presented in Table 3 and figure 3

Table 3. EFs in the Structural Equation Model of Predicting O-NET scores

Latent Variable	*EFs*					*O- net*				
Observed Variable	*b*	*SE*	β	*t*	R^2	*b*	*SE*	β	*t*	R^2
DF	1.136	0.184	0.451	6.188**	0.204					
DB	1.263	0.154	0.584	8.186**	0.341					
TMT A	-3.756	0.480	-0.555	-7.820**	0.308					
TMT B	-15.390	2.155	-0.511	-7.141**	0.261					
English						17.863		0.818		0.670
Math						17.720	1.444	0.763	12.274**	0.582
Science						11.519	1.034	0.704	11.144**	0.495

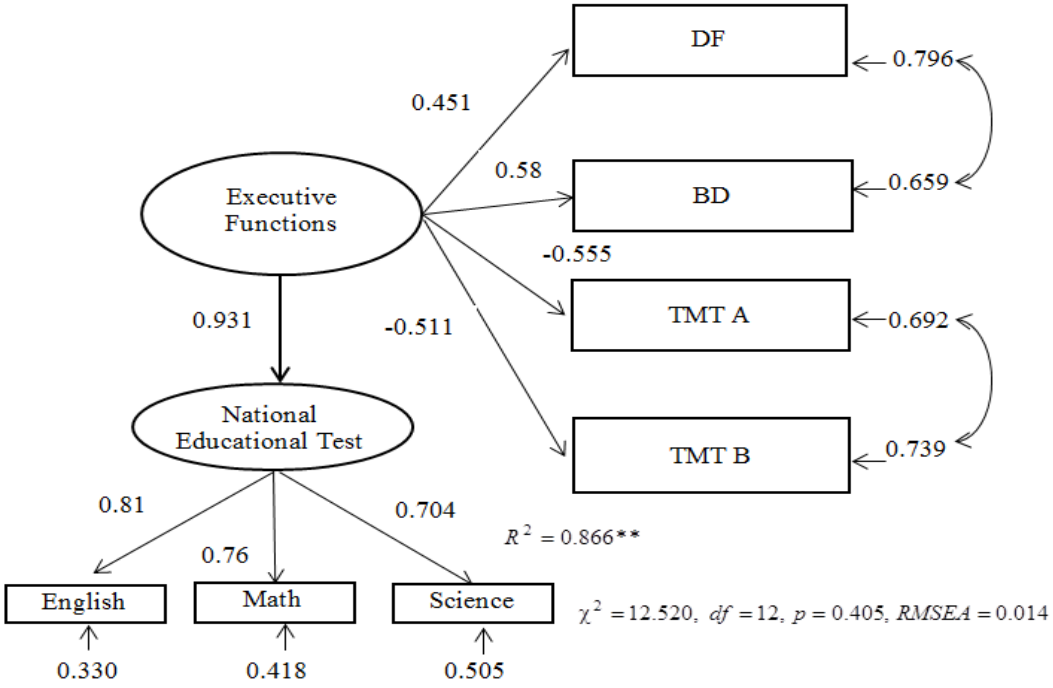

Figure 3.The mixture model for EFs predicting O-NET scores.

DISCUSSION

EFs are the effects of development that are an important change across life span. Children are expected to see improvement over time in focus, engagement, achievement, and daily living performance (Blair &Diamond, 2008, Mulder, Hoofs, Verhagen, et al, 2014). There are a

number of neuropsychological assessments that can be used to investigate aspects of executive function. This study to clarify the relationship between EFs and O-NET scores in Thai adolescences. There are three aspects of this discussion. Frist, the EFs test for using CFA. It appeared that the Digit Span and TMT are significantly and directly related to EFs. The finding that similarity to a DB task influences EFs is consistent with the participants between 8 and 15 years of age (Prencipe, Kesek, Cohen, Lamm, Lewis, & Zelazo, 2011). In the findings related to TMT task that in identified EFs, these findings also confirm the findings of previous study (Tombaugh, 2004); Morgan & Lilienfeld, 2000). One possible interpretation of these results is that the hypothesis of four tasks also identified to the performance of EFs. As Brydges et al. (2012, 2014) and Friedman et al. (2006) administered neuropsychological assessment to confirm three factors of EFs such as update of working memory, task shifting, and inhibition. Therefore, measurement model of SEM analysis confirm that four observed variables were identified executive functioning among adolescence in Thailand.

Second, the researchers examined associations between English, Mathematics, and Science scores has significantly prognosticated national educational testing scores in adolescence. According to the available of the CFA as a statistical approach, the previous results were interpreted in Reading, Writing, and Mathematics that was related academic achievement. Moreover, the previous research showed that information based on nationally comparable grades of the final assessment of basic education that permitted a representative and comprehensive estimating of adolescents' academic achievement. (Kantomaa et al, 2013).For Cole, Bergin, and Whittaker, 2008 provided that achievement assessments according to the UK National Curriculum criteria for Mathematics, English, and Science predicted the school achievement. Furthermore, the latent variables with the added O-NET scores are just-identified model.

Finally, the focus of the present study was to examine relationships between executive functioning and O-NET scores. The Mixture Modeling was used to explore the psychometric quality of an EFs task effect to O-NET scores. Miyake et al., 2000 discussed the measures used to apply the three target EFs (i.e., shifting, updating, and inhibition). The research that described executive functioning abilities attain in English, Mathematics, and Science (St Clair-Thompson & Gathercole, 2006). The results are also consistent with previous studies of associations between working memory span tasks and national curriculum test scores in children with 7, 11, and 14 years of age(Gathercole & Pickering, 2000; Gathercole et al., 2004). The importance of these described EFs play a prominent role in several existing theoretical accounts of children's academic, literacy, science, and learning skills. (Bull, & Lee, 2014; van der Ven, Kroesbergen, Boom, & Leseman, 2012; Neuenschwander, Rothlisberger, Cimeli, and Roebers, 2012). According to this analysis, the study performed very well for the models investigated in EFs able to determine the O-NET scores.

The ability of executive assessments to also predict national educational test score in the Thai adolescent population deserve consideration so that the assessment of executive functions will be recognized in develop achievement, with the aim of predicting possible improvement in national educational test. Further, we recommend follow the development of a model including these finding as highly desirable. The EFs was also a main issue for improving academic achievement, the intervention with physical activities that improve working memory, inhibition, and flexibility are used in adolescence school (Monette, Bigras, &Guay. 2011; Biddle, & Asare, 2011; Davis et al, 2011).The researchers offer the recommendation for future research in the area of educational achievement identity and identified statistical:

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studying Thai national educational test ability and other ASEAN country identity as a process with multiple group statistically model, and examining EFs identity enactment in other educational test score such as administrations of PISA.

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