Factors influencing executive functions of the brain in Thai adolescents[1]

Assist. Pr. Dr. Juthamas HAENJOHN*
Assist. Pr. Dr. Warakorn Supwirapakorn *
Dr. Sasinan Sirithadakunlaphat*
*Dept. of Research and Applied Psychology, Faculty of Education, Burapha University, THAILAND

Abstract

The objectives of this developmental research were: 1) to study the levels and factors that influence executive functions of the brain in adolescents, 2) to study the current state and practical method for developing executive functions of the brain in adolescents (EFs). The methodology consisted of 2 phases. Phase I was a quantitative study about the levels and the influencing factors of the executive functions of the brain in adolescents. Data was collected from 1200 junior high school students through multi-stage random sampling. The instrument used was the Thai version of the Behavior Rating Inventory of Executive Function-Self-Report (BRIEF-SR). Data were analyzed by One-way Analysis of Variance. Phase II was a qualitative study based on the content analysis of an interview of 24 students and 12 teachers. The results revealed that 1) gender, age, academic achievement, amount of sleep, drug use, and mindfulness practice had effects on the executive functions of the brain with statistical significance of .05, 2) almost teachers and students lacked perception and knowledge on the executive functions of the brain. Students had behaviors that indicated an executive dysfunction of the brain. In addition, they needed training to enhance their executive functions of the brain through group training skills.

Keywords

Executive Functions, Adolescent, Neurosciences

Introduction

During the world changes of the 21st century, people need to have cognitive skills to adjust themselves when dealing with the changes. A new trend of studies in

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integrative psychology, neuroscience and education have focused on enhancing human cognitive fuctions that effect learning abilities. Executive functions (EFs) of the brain are the cognitive functions composed of three important components: inhibitory control, working memory and cognitive flexibility or mental flexibility (Lehto et al., 2003; Miyake et al., 2000; Diamond, 2013). Research studies have shown that EFs may have influence on people's everyday life activities, academic achievement, ability to work, and life success. Cognitive skills change is the result of the maturity of the prefrontal cortex (Gilbert & Burgess, 2008). Thus, EFs skills begin to develop from 2 years old (Panesi & Morra, 2016), school age, and during adolescent (Zelazo et al., 2013). Previous research studies indicated that gender, age, academic achievment, sleepiness, drug use, and mindfulness practice influence the EFs development.

Thus, the purposes of this study were to investigate the level and factors influencing EFs of Thai adolescents in the Eastern part regions (Quantitative study) and to study factors that influence EFs of Thai adolescent in the Eastern part regions (Qualitative study). The research findings benefit the development of the program in enhancing the EFs of adolescents.

Methodology

Phase 1:

***Participants*:** The sample was 1,200 students (569 males; 631 females; age between 11-15 years old), who studied in four secondary schools in the Eastern region of Thailand. The sample was selected through multi stage sampling.

***Instrument*:** The Behavior Rating Inventory of Executive Function-Self-Report (BRIEF-SR) assesses adolescents executive functioning (Guy, Isquith, & Gioia, 2004). It contains 80 items, each of which is rated on a 3-point Likert scale items that indicated the extent to which the adolescent behavior never occurred, sometimes occurred, or occurred often. Higher scores mean less adequate executive functioning. The composite raw score for the Global Executive Composite (GEC) includes the Behavioral Regulation Index

(e.g. Inhibit, shift, emotional control) and Metacognition Index (Monitor, working memory, plan/ organize, organization of materials, and task completion). The BRIEF-SR was translated into Thai (Haenjohn, 2017). In the present study, the BRIEF-SR: Thai version demonstrated good reliability (Cronbach's $\alpha = .94$) and validity.

***Statistic Analysis*:**

The data was analyzed through ANOVA (Analysis of Variance statistical test). When we found the interaction or significant of the main effects or simple

effect, Pairwise Comparisons were utilized on the variable. To prevent the experiment wise error rate from inflating when the analysis was conducted (type 1 error), the alpha level was adjusted by using the Bonferoni procedure.

Phase 2:

***Participants*:** The sample was 24 students (12 males and 12 females, 11-15 years old), who studied in four secondary schools in the Eastern region of Thailand, and 12 teachers in the same schools. The sample was selected through simple random sampling. The sample participated voluntarily in the study, and each subject signed a written informed consent. This research received ethics approval from Burapha university research ethics review board. The students were interviewed in depth and teachers were inteviwed in the focus group. Each group is composed of 3-4 teachers.

***Instrument*:**

The researchers developed the semi-constructed interview questionnaire in order to inquire about the current state, need assessment, and best practice of executive functions development. This questionnaire was tested for construct validity by three experts of neuroscience, psychology and psychiatry.

***Data analysis*:**

The content analysis was utilized for data analysis by dividing the content into 4 domains: 1) perception of executive functions in adolescents, 2) understanding the executive functions in adolescents, 3) need of executive functions training in adolescents, and 4) factors of executive functions devevelopment in adolescents.

Results

Phase 1:

The results of level and factors influencing EFs revealed as follows:

1. Thai adolescents EFs dysfunctions mean score was 139.67; SD=15.
2. Female adolescents had an EFs dysfunctions mean score (140.06; S.D.=20.25) higher than male adolescents (mean139.23, S.D.=20.05) (F= 0.497, p = 0.481).
3. Female adolescents had an EFs dysfunctions mean score (BRI, Emotional control, Working memory, and Organization of materials) higher than male adolescents (p<.05).

4. Adolescents with a GPA ≤ 2.75 had a higher mean score of EFs dysfunctions (GEC) than adolescent with a GPA 2.76 - 3.00 (F=p<.05) and higher than those with a GPA ≥ 3.51 (F=13.347; p<.05).
5. Adolescents with a GPA 3.01-3.50 had a higher mean score of EFs dysfunctions (GEC) than adolescents with a GPA ≥ 3.51 (p<.05).
6. Adolescents who sleep less than 6 hours had EFs dysfunctions (GEC) higher than adolescents who sleep more than 6 hours (F=4.23, p < .05), but no different in adolescents who sleep 6-8 hours > 8 hours.
7. Adolescents who sleep less than 6 hours had EFs dysfunctions (Emotional control, Plan/ Organize, Organize of materials, Task complete and MI) higher than adolescents who sleep more than 8 hours.
8. Adolescents who are sleepy had EFs dysfunctions than adolescents who sleep well (GEC) (Anderson et al, 2009).
9. Drug user adolescents had EFs dysfunctions mean score higher than non-drug user adolescents (F=35.678, p < .05).

Phase2:

The contents analysis showed that:

1. Almost teachers and students lacked perception and knowledge on the executive functions of the brain.
2. Students had behaviors that indicated an executive dysfunction of the brain.
3. Teachers and adolescents were willing to participate in the strengthening EFs training program. Ninth grade student needed training to strengthen their executive functions of the brain through group training skills.
4. Factors of executive functions development in adolescent were: 1) parents education, 2) child-rearing practices, 3) developing EFs in the classroom, and 4) the cooperation with parents to enhace EFs skills of adolescents.

Conclusion

In the present sudy, we examined the level and factors influencing executive functions of the brain in Thai adolescents in the East region of Thailand. The results in the quantitative phase revealed that the EFs dysfunctions mean score of Thai adolescents = 139.67; SD=15. Female adolescents had an EFs dysfunctions mean score higher than male adolescents (p<.05). Previous research found that Prefrontal cortex (PFC) of male adolescents, aged 10-16 years old, had more functions than female adolescents (Alarcon, Cservenka, Fair, & Nagel, 2014). Moreover, male adolescents had a higher EFs component in inhibitory control abilities than female adolescent during a period (Colzato et al., 2010). When considering each domain, the present study found that female adolescents had lower EFs dysfunctions mean scores than male adolescents in monitoring,

planning, organizing, and completing tasks than female adolescents (p<.05). The previous study indicated that female adolescents with Dorsolateral Prefrontal Cortex (DLPFC) and Right parietal cortex functionws better than male. But male adolescents had Precuneus did more function of Visualspatial abilities than female adolescents (Boghi et al., 2006). Adolescents aged higher than 14 years old had an EFs dysfunctions mean score higher than adolescents aged between 11-14 years old ($p<.05$). Our findings support the previous study of Guy, Isquith, & Gioia (2004) and the meta-analysis of Romine & Reynold (2005) who found that the developmental trajectory of EFs development increases during the age of 5-8 year old, remains steady during the age of 8-14 years old and decreases during the age of 14-17 years old. Low Grade Point Average (GPA) adolescents had EFs dysfunctions mean score higher than high GPA adolescents ($p<.05$). This result confirmed many research studies which indicated that EFs are linked to academic achievement (Clair-Thompson & Gathercole, 2006; Best, Miller, & Naglieri, 2011). Thus, high GPA adolescents had EFs dysfuntions less than low GPA adolescents ($p<.05$; Haenjohn, 2017). Many studies found the association between amounts of sleep and executive functions in adolescents (Anderson et al., 2009). The present study yielded that adolescents with less sleep had an EFs dysfunctions mean score higher than the adolescents who sleep well ($p<.05$). We also found that drug user adolescents had an EFs dysfunctions mean score higher than non-drug user adolescents ($p<.05$). This result is in congruence with the previous studies (Briona, et al., 2017; Rose-Jacobs et al., 2017; Spinola et al., 2017). Lastly, we examined the notion of mindfulness in the activities of our EFs training program. We found that non-mindfulness practice adolescents had an EFs dysfunctions mean score higher than mindfulness practice adolescents ($p<.05$). This finding supports previous studies that mindfulness practices affect EFs development (Bhargav et al., 2016; Gallant, 2016; Hölzel et al., 2011; Short et al., 2016).

The contents analysis of the in-depth interviews of 24 adolescents (6 persons per school) and focus group interviews of 12 teachers (3-4 persons per school) of the present study wer catagorized into 4 domains: perception understanding, need of executive functions training, and factors of executive functions devevelopment in adolescents (See figure 1).

The findings showed teachers' general perception and understanding. They did not understand the concept of executive functions of the brain (e.g., important processes, functions, and development). It was not different for students either. Students lacked perception and knowledge of the executive functions of the brain as well because they had not studied the brain anatomy and functions from the sixth to ninth grade. Moreover, they had behaviors that indicated an executive of the brain dysfunction. Especially, dysfuntions in habit, emotional control, and working memory skills. Teachers and adolescents were willing to participate in the strengthening EFs training program. Ninth grade student needed training to strengthen their executive functions of the brain through group training.

The EFs training program shoud contain discussion, relaxing, and fun activities. The program should be 1-2 days or 1-2 times per week. Guidance teachers should be trained to be the trainer of the EFs training program so that they can develop the EFs of the adolescent students. Factors of executive functions devevelopment in adolescent were: 1) parents who have a college education, 2) child-rearing practices providing freedom, warmth and caring, 3) teachers developing EFs in adolescents in the classroom accidentally without the knowledge of EFs. The teachers need to cooperate with parents in order to enhance the EFs skills of adolescents. It is illustrated in the diagram below:

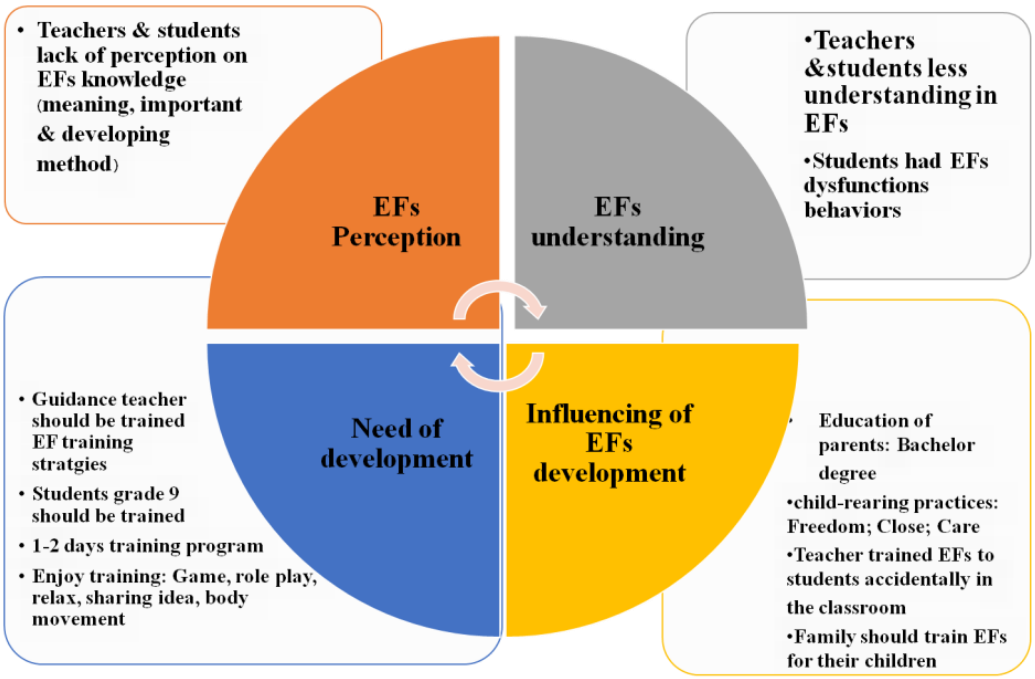

Figure1: Content analysis of factor incluenceing executive functions

It could be concluded that gender, age, academic achievement, sleepiness, drug use, mindfulness practice, education of parents, child-rearing practices, and EFs training in the classroom by the teacher, influence the EFs of Thai adolescents.

Further works

1. The research findings benefit the development of the program enhancing EFs of adolescents.
2. Adolescents should be trained to develop their EFs by their teachers and family.
3. It should contribute EFs knowledge to schools and families.
4. EFs training should be established in the national policy.
5. EFs may affect emotional control, decision making, reasoning and problem solving in the current 'post-truth' world.

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