THE CORRELATION ANALYSIS BETWEEN THE VISUAL-MOTOR INTEGRATION AND THE TASK OF EXECUTIVE CONTROL IN SCHOOL-AGED CHILDREN

KRITTIYANEE THAMMASARN

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....
Miss Krittiyanee Thammasarn
Candidate

....
Lect. Vasunun Chumchua, D.Sc.
Major advisor

....
Lect. Panadda Thanasetkorn, Ph.D.
Co-advisor

....
Assoc. Prof. Nuanchan Chutabhakdikul, Ph.D.
Co-advisor

....
Prof. Banchong Mahaisavariya,
M.D., Dip. Thai Board of Orthopedics
Dean
Faculty of Graduate Studies
Mahidol University

....
Lect. Kaewta Nopmaneejumruslers,
M.D.
Program Director
Master of Science Program in
Human Development
National Institute for Child and
Family Development
Mahidol University

Thesis
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on
April 9, 2014

Krittiyanee Thammasarn
....
Miss Krittiyanee Thammasarn
Candidate

....
Lect. Piyavalee Thanasetkorn, Ph.D.
Chair

....
Lect. Vasunun Chumchua, D.Sc.
Member

....
Assoc. Prof. Nuanchan Chutabhakdikul, Ph.D.
Member

....
Lect. Panadda Thanasetkorn, Ph.D.
Member

....
Prof. Banchong Mahaisavariya,
M.D., Dip. Thai Board of Orthopedics
Dean
Faculty of Graduate Studies
Mahidol University

Suriyadeo Tripathi
....
Lect. Suriyadeo Tripathi, M.D.
Director
National Institute for Child and
Family Development
Mahidol University

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KRITTIYANEE THAMMASARN 5536923 CFHD/M

M.Sc. (HUMAN DEVELOPMENT)

THESIS ADVISORY COMMITTEE: VASUNUN CHUMCHUA, D.Sc.,
PANADDA THANASETKORN, Ph.D., NUANCHAN CHUTABHAKDIKUL, Ph.D.

ABSTRACT

Generally, parents expect their children to get the best academic achievements. Around, 75% of all classroom learning is visual-motor integration, visual-motor integration is a basic development which is used for executive function. In Thailand, it has also been reported by the National Council for Child and Youth Development (NCYD) during the years 2004 – 2006, that of 23 million children and youths, 1.7 million of them has been found to have writing disabilities. Mostly in the northeastern region of Thailand, this phenomenon may lead to cognitive performance deficits later on. Previous studies have developed the assessment program to evaluate visual-motor integration and executive function in children. Keith Beery developed VMI as a standardized instrument for evaluating the extent to which individuals could integrate their vision and motor abilities. In the meantime, the assessment tool for using to measure executive functions has also been developed. The Task of Executive Control (TEC) is another computer administered instrument measuring two fundamental aspects of executive functions, such as working memory and inhibitory control. However, the visual-motor integration performance is fundamental based on the development of executive functions but there have not yet been any studies on the correlation between VMI and TEC. Therefore this study aimed to investigate the correlation between the visual-motor integration (VMI) and the task of executive control (TEC) in school-aged children

Correlation research design with multistage sampling method was applied in this exploratory research. The total sample was 123 children who were aged 7 to 9 years. The sample also rated the child's visual-motor integration skills, using the The Beery-Buktenica Developmental Test of Visual-Motor Integration (VMI) 6thedition**.** The sample also rated the child's EF skills**,** using the Task of Executive Control, a standardized instrument for measuring the working memory and inhibitory control skills of school-aged children. The results showed significantly positive correlations among the two sets of subscale data.

The results showed that the Visual-Motor Integration had a significantly positive correlation with the Task of Executive Control ($p < .01$). These findings indicated some predictive correlation between the visual-motor integration, working memory and inhibitory control. The implications, limitation and suggestions are discussed.

KEY WORDS: VISUAL-MOTOR INTEGRATION / EXECUTIVE CONTROL
WORKING MEMORY / INHIBITORY CONTROL /
SCHOOL-AGED CHILDREN

95 pages

การศึกษาความสัมพันธ์ระหว่างการประสานสัมพันธ์ของสายตาและกล้ามเนื้อสั่งการและกระบวนการคิดขั้นสูงในเด็กวัยเรียน
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กฤติยาณี ธรรมสาร 5536923 CFHD/M

วท.ม. (พัฒนาการมนุษย์)

คณะกรรมการที่ปรึกษาวิทยานิพนธ์: วสุนันท์ ชุ่มเชื้อ, D.Sc., ปนัดดา ธนเศรษฐกร, Ph.D., นวลจันทร์ จุฑาภักดีกุล, Ph.D.

บทคัดย่อ

เป็นที่ยอมรับว่าผู้ปกครองส่วนใหญ่คาดหวังที่จะให้ลูกประสบผลสำเร็จในการเรียน จากการศึกษาพบว่า 75% ของการเรียนรู้ให้ห้องเรียนใช้การประสานสัมพันธ์ของสายตาและกล้ามเนื้อสั่งการ ซึ่งการประสานสัมพันธ์ของสายตาและกล้ามเนื้อสั่งการจะเป็นพื้นฐานที่สำคัญของกระบวนการคิดขั้นสูงของเด็ก สภาองค์การพัฒนาเด็กและเยาวชนแห่งประเทศไทย รายงานผลสำรวจในปี 2547-2549 พบว่า เด็กวัยเรียนและวัยรุ่น 1.7 ล้านคน จากจำนวนเด็กทั้งหมด 23 ล้านคน มีปัญหาทางด้านการเขียนและกระบวนการคิดรู้ ส่วนใหญ่พบได้ในตะวันออกเฉียงเหนือของประเทศไทยซึ่งจะมีผลต่อกระบวนการคิดขั้นสูงในเวลาต่อมาได้ ทำให้ได้มีการพัฒนาแบบประเมินเพื่อใช้วัดการประสานสัมพันธ์ของสายตาและกล้ามเนื้อสั่งการและกระบวนการคิดขั้นสูง เคท เบอรี่ ได้พัฒนาเครื่องมือการประสานสัมพันธ์ของสายตาและกล้ามเนื้อสั่งการ (VMI) เพื่อประเมินความสามารถทางสายตาและกล้ามเนื้อสั่งการ และในขณะเดียวกัน เครื่องมือทดสอบกระบวนการคิดขั้นสูง (TEC) ก็ได้มีการพัฒนาขึ้นมาเพื่อใช้ประเมินกระบวนการคิดขั้นสูงของสองส่วนหลักใหญ่คือ ความจำขณะทำงานและการยับยั้งชั่งใจ แต่ถึงอย่างไรก็ตาม แม้จะพบว่าการประสานสัมพันธ์ของสายตาและกล้ามเนื้อสั่งการจะเป็นพื้นฐานที่สำคัญของกระบวนการคิดขั้นสูง แต่ยังไม่มีผู้ศึกษาความสัมพันธ์ระหว่างเครื่องมือการประสานสัมพันธ์ของสายตาและกล้ามเนื้อสั่งการ (VMI) และเครื่องมือทดสอบกระบวนการคิดขั้นสูง (TEC) ดังนั้น การศึกษาครั้งนี้จึงมีวัตถุประสงค์เพื่อตรวจสอบความสัมพันธ์ระหว่างเครื่องมือการประสานสัมพันธ์ของสายตาและกล้ามเนื้อสั่งการ (VMI) และเครื่องมือทดสอบกระบวนการคิดขั้นสูง (TEC) ในเด็กวัยเรียนอายุระหว่าง 7 ถึง 9 ปี

งานวิจัยนี้เป็นการศึกษาความสัมพันธ์ ลักษณะการวิจัยเชิงสำรวจ ใช้วิธีการสุ่มตัวอย่างแบบหลายขั้นตอน กลุ่มตัวอย่างที่ใช้ในงานวิจัยมีทั้งหมด 123 คน เป็นเด็กวัยเรียนอายุระหว่าง 7 ถึง 9 ปี การจัดอันดับทักษะการประสานสัมพันธ์ของสายตาและกล้ามเนื้อสั่งการ ใช้แบบทดสอบการประสานสัมพันธ์ของสายตาและกล้ามเนื้อสั่งการ ฉบับปรับปรุงครั้งที่ 6 และ การจัดอันดับทักษะกระบวนการคิดขั้นสูง ใช้แบบทดสอบกระบวนการคิดขั้นสูงที่เป็นแบบประเมินมาตรฐานในการประเมินทักษะความจำขณะทำงานและทักษะการยับยั้งชั่งใจในเด็กวัยเรียน จากผลการศึกษาพบว่ามีความสัมพันธ์เชิงบวกในแต่ละหน่วยย่อยของทั้งสองเครื่องมือ

ผลการศึกษาครั้งนี้ชี้ให้เห็นถึง เครื่องมือการประสานสัมพันธ์ของสายตามีความสัมพันธ์ทางบวกกับเครื่องมือกระบวนการคิดขั้นสูงอย่างมีนัยสำคัญทางสถิติที่ระดับ $p < .01$ การค้นพบนี้ชี้ให้เห็นถึงความสัมพันธ์ที่คาดการณ์บางอย่างระหว่างความสัมพันธ์ของการประสานสัมพันธ์ของสายตาของเด็กและความจำขณะทำงานและการยับยั้งชั่งใจ ผลกระทบ ข้อจำกัด และข้อเสนอแนะที่จะกล่าวถึงต่อไป

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VMI	The Visual-Motor Integration
TEC	The Task of Executive Control
TVPS	The Visual-Perceptual Skills
WCST	Wisconsin Card Sorting Task
TOH	Tower of Hanoi
MFFT	Matching Familiar Figures Test
ROCF	Rey-Osterrieth Complex Figure
ADHD	Attention Deficit Hyperactivity Disorder
WISC-R	Revised Wechsler Intelligence Scale for Children
DTVP-2	Developmental Test of Visual Perception
WRAVMA	Wide Range Assessment of Visual Motor Abilities
CTBS	Comprehensive Test of Basic Skills
WISC-R	Revised Wechsler Intelligence Scale for Children
CPRS-R:L	The Conners' Parent Rating Scales-Revised Ling Form
CBCL	The Child Behavior Checklist
PCSI	Parents and teachers and developmentally specific self-report forms
ESS	Everyday Situation Survey
FAD	Family Assessment Device

CHAPTER I
INTRODUCTION

1.1 Background and Rationale

Generally, parents expect their children get the best academic achievements. Therefore several interventions had been developed to improve children's academic performance, the children in each country around the world could attend special training programs for visual-motor integration from teachers and parents. To be considered that 75% of classroom learning requires visual-motor integration performance. Consequently, the rest of a child who has either poor or mild visual-perceptual becomes to struggle with learning ability in the classroom (20, 37). Noteworthy, the handwriting skill is one of most to support learning skills in the elementary years. Children need visual-motor integration to acquire writing, visual perception for processing visual information, motor coordination for organizing, remembering, and recognition of information for moving hands to write (4). In addition, the ability of visual-motor integration is essential for daily life or functioning and acting in coordination with visual perception and body motion. Visual-Motor Integration is a milestone of early childhood development by age. In young children, visual-motor integration is beginning from simple skills such as holding the spoon capability further to more complex skills such as cycling in older children. (1). It has also been reported that the ability of visual-motor integration skills shown the positive relation to academic skills and development in the next grade levels (2), school achievement including learning readiness, reading, and mathematics skill (3).

As the mention of above, visual-motor integration is correlated with academic skills and development in the next grade levels. Writing skill is one essential academic skill for academic achievements. So in Thailand, It has also been reported by the National Council for Child and Youth Development (NCYD) during Year 2004 – 2006, in 23 million children and youths, 1.7 million of them has been found writing disabilities, that mostly in the northeastern region of Thailand (17). However, the handwriting ability in children is actually performed by the achievement of visual-motor integration. Considering, that vision is a primary sensory modality (5). The lineage of Visual development is goes through first two years after birth and rapidly develops in early 6 months. This development is using for attention, tracking, and visual perception. Visual perception is the ability to attention in both eyes onto an object for perceived vision. It has been developed by age and full development at the age of 7 (6). During those period, motor has also developed simultaneously, motor development is a gradual process by children using for their move to motion, and the coordination of motor skills (7). The motor coordination capability is defined with speed and accuracy (8). Older children achieve a great deal of coordination in their activities. They represent better speed motors and control accuracy than young children, which means that children's motor integration becomes to mature by age of five or six (9). *(As shown in Figure 1.1)*

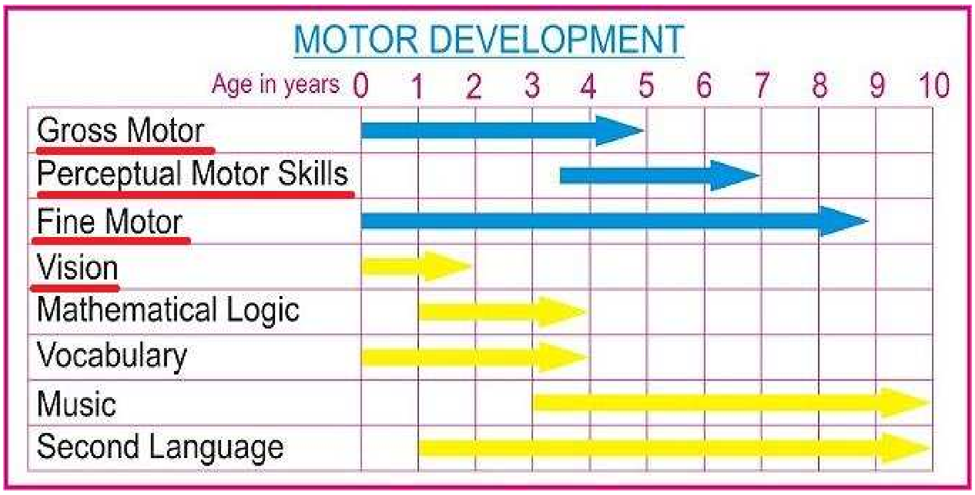

Figure 1.1 Motor Development

This figure presents the development of motor. The arrow shows windows of opportunity for motor development. Vision is a primary sensory established in birth and will be completed in 2 years. Gross motor will be fully development at 5 years old. Fine motor is a complex skill and fully developed at 9 years old (9).

Visual-motor integration is basis development which using for cognitive process of executive function, which means that an ability to transform visual inputs into movement plans and motor-executive skills (10), especially working memory and inhibitory control are responsible for maintaining the stimulus of the action plan and regulating themselves (11,12). Working memory and inhibitory control tasks are gradually developed during infancy and increase during childhood and preadolescence. The studied of age-related executive function in the normative sample, showed that working memory and inhibitory control was highest in the 7 to 9 year olds (6). Similar findings has also been reported that the high level of memory and inhibition tasks, executives function, found in age between 3 to 6 years (13). However, preschool children are normally incomplete of management control (14) until they becomes at ages between 8 and 9 years old. Children shows a significantly increase in task of working memory and response inhibition (15). *(As shown in Figure 1.2)*

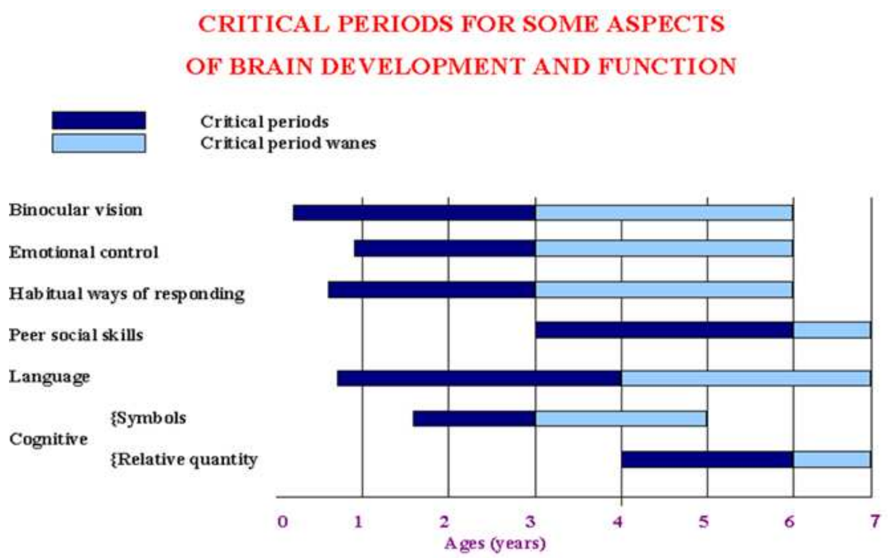

Figure 1.2 Critical periods of brain development and function. This figure represents the development of brain. The line shows critical periods of cognition between 4 to 6 years, after binocular vision, emotional control, and habitual ways of responding are complete (15).

From several studies may concluded that three domains of working memory and inhibitory control, which include attention, speed, and accuracy. These domains involve the processing systems in the brain to respond, pay attention, and remember details in situations that require children to manage speed, and conduct and inhibit themselves for accuracy behaviors (9). Memory and inhibition directly result to handwriting. A research showed that handwriting performance significantly had impacts on children's memory and inhibition. Children who have more working memory and inhibitory control are able to manage their eyes and hand movement tends to have higher ability to control their handwriting (5, 7)

Previous studies have developed the assessment program for visual-motor integration, working memory, and inhibitory control in children. In 1994, Keith Beery developed a standardized instrument for evaluating the extent to which individuals could integrate their vision and motor abilities (eye-hand coordination). Four of the geometric forms been selected to assign and included in the final 30 items. Each subscale included visual perception and motor coordination. Likewise, the previous research also focused on the Visual-Motor Integration and included visual perception and motor coordination. In addition, the Visual-Motor Integration (VMI) has been done in Thai children for evaluating visual-motor integration (16). Previously, the relationship between VMI and others instruments had been studied, but most studies focused on the visual and motor performance (51). In the meantime, the assessment tool for using to measure the executive function had also been developed. The Task of Executive Control (TEC) is another computer administered instrument measuring two fundamental aspects of executive functions such as working memory and inhibitory control. The previous studies on the relationship of TEC and other instruments showed that TEC emphasized the relationship with many cognition instruments (52). However, the visual-motor integration leads to the development of executive function there have not yet been studies on the relationship between VMI and TEC.

1.2 Research Questions

The research question of this study was:

- Are there any statistically significant correlations between each subscale of Visual-Motor Integration, as measured by the Visual-Motor Integration (VMI) and each subscale of Executive Control, as measured by the Task of Executive Control (TEC) in school-aged children ?

1.3 Research Hypothesis

The hypotheses of this study were:

- H_0: There were no statistically significant correlations between the subscales of Visual-Motor Integration as measured by the Visual-Motor Integration (VMI) and the subscales of Executive Control as measured by the Task of Executive Control (TEC) in school-aged children
- H_1: There were statistically significant correlations between the subscales of Visual-Motor Integration as measured by the Visual-Motor Integration (VMI) and the subscales of Executive Control as measured by the Task of Executive Control (TEC) in school-aged children

1.4 Objective of the Study

- To investigate the correlations between each subscale of Visual-Motor Integration, as measured by the Visual-Motor Integration (VMI) and each subscale of Executive Control, as measured by the Task of Executive Control (TEC) in school-aged children.

1.5 Conceptual Framework

This research examines the correlations between the subscales of Visual-Motor Integration (VMI) and the subscales of Task of Executive Control (TEC) in Thailand.

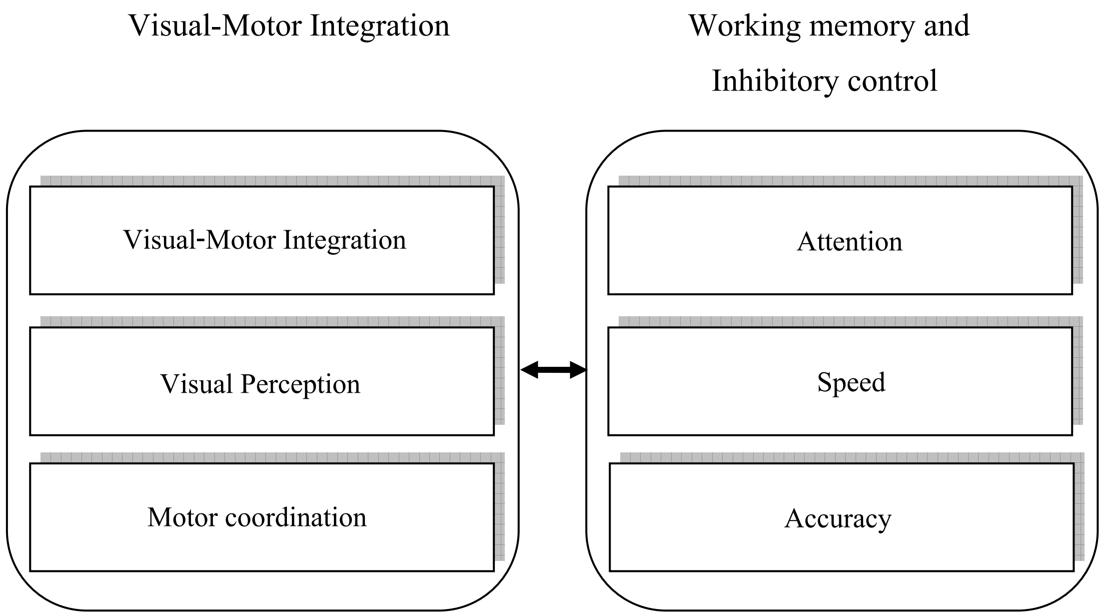

Figure 1.3 Conceptual framework

1.6 Scope of the Study

This study focuses on the correlations between the Visual-Motor Integration (VMI) and the Task of Executive Control (TEC). The subjects were the school-aged children, who were studying in the primary school level, educational year of 2013 in the supervision of Education Service Area Office, Nakornratchasima, Thailand. Each subscale of Visual-Motor Integration and the Task of Executive Control was indicated by the standardized instruments such as Visual-Motor Integration (VMI) and Task of Executive Control (TEC) respectively.

1.7 Expected Benefits

- To actually learn about the correlation between the Visual-Motor Integration (VMI) and the Task of Executive Control (TEC).
- To support parents and teachers for planning for intervention and special training programs for school-aged children with visual-motor integration deficit.

1.8 Definitions and Abbreviations

To understand key concepts throughout this study, it is important to highlight a few key terms.

1.8.1 The Visual-Motor Integration (VMI)

Visual Motor Integration (VMI) is the ability of eyes and hands to work together in a smooth, efficient format. It involves visual perception and motor coordination. Visual-Motor integration requires the ability to recognize visual translated into the motors and associated with motor control, motor accuracy, motor coordination and speed.

1.8.1.1 Visual perception is the ability to interpret the environment by processing information contained invisible light perception occurs is known as the sight or vision.

1.8.1.2 Motor coordination is a combination of body movements created with the kinematic and movement (force) parameters that result in intended actions.

1.8.2 Executive Control (EC)

Executive Control (EC) is higher-order cognitive process carried out by prefrontal areas of the frontal lobe. These processes control and regulate thought and behaviors. There are including inhibition, shifting, and emotional control, working memory and planning/organization.

1.8.2.1 Working memory is the ability to maintain and manage information on the period of time. The incoming information must be in an accessible state temporarily and can be replacement by newly incoming information. Important component of working memory is monitoring and coding of incoming information to manipulate it.

1.8.2.2 Inhibitory control is the ability to suppress the automatic response or before the stimulation and control potential interference. Including motor control and emotional control.

1.8.3 School age children

School-aged children means children at age of 7-9 whom studying at the primary school, Education Year 2013 under the supervision of Education Service Area Office, Region 7, Nakornratchasima Province, Thailand.

In the next chapter, a substantial amount of research in each subscale field was reviewed. The review of literature related to visual-motor integration, development of brain functions and executive function skills, subscales of visual-motor integration, subscales of working memory and inhibitory control, and instrument for measuring the visual-motor integration and the task of executive control are presented.

CHAPTER II
LITERATURE REVIEW

This research investigated the relationships between Visual-Motor Integration (VMI) and Task of Executive Control (TEC). Since the previous studies on children's executive control were still limited and the research studies on the relationships between Visual-Motor Integration and children's Executive Control were also rare. Therefore this study purposed to study the correlation between VMI and TEC in school-aged children.

This chapter probides the review of relevant literature which composed of 3 sections. First, a substantial amount of research in visual-motor integration and brain development was reviewed to point out the aged-appropriate development of brain functions and executive function skills. Second, the studies in the subscales of visual-motor integration, working memory, and inhibitory control were reviewed to explain the important components of the visual-motor integration, working memory, and inhibitory control. Finally, the third section reviewed the instruments for measuring the Visual-Motor Integration and Executive Control.

2.1 Visual-motor integration, brain cognitive development and executive function in school-aged children

Visual-Motor Integration (VMI) is the ability to match its motor output with visual input. It refers to the complex process of integrating information from visual and motor system to achieve the best movement patterns with the most accurate and cost-effective in terms of energy and time (10). Sensory integration research has shown the relationship between children's brain development and visual-motor integration.The brain function is basically superior to control and organize the motor output to sensory processing. Cerebral cortex areas are significantly authorize to human being because these areas are related to the part of sensory involved with visual-motor integration processing.

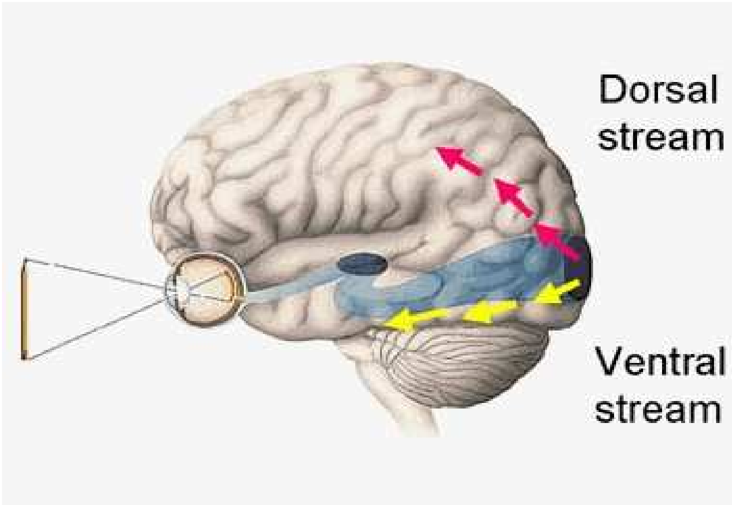

Figure 2.1 Ventral and dorsal stream

This figure shows the ventral and dorsal stream. The pink arrow shows the dorsal stream into the parietal lobe and is involved with processing the object location, in order to program behaviors. The yellow arrow shows the ventral stream sent to the temporal lobe and is involved with object identification and recognition in order to plan behaviors (20).

Visual-motor integration process consists of two main pathways, or streams for visual perception and motor action. Process of visual system in humans at occipital lobe involves certain two distinct. Goodale & Humphrey conducted a research study on the objects of action and perception. The findings showed that the difference between visual perception and visual action was reflected in the organization of the visual pathways in primate cerebral cortex. Figure 2.1 demonstrates the ventral and dorsal stream by Goodale & Humphrey (1998). The dorsal stream into the parietal lobe involves the processing of object location in order to program behaviors and the ventral stream sent to the temporal lobe involves the object identification and recognition in order to plan behaviors (20). Teresa Farroni and Enrica Menon (2008) conducted a research study on the processes of brain development and visual motor functioning. The findings showed that the children aged between 5 and 7 years old completed their development of basic functions of early sensory areas of the cortex, and the functional development of brain in 8 to 9 years can recognize the complex sense of visual and motor integration (24). Visual motor processes may be detected in young children, which are likely to be fundamental to the development in different behaviors later (25). Human behaviors relate many brains areas and functions. The first 6 years of children afterbirth is the critical period of frontal cortex development (15), the neural density of the frontal lobes begins about 7-9 years of age and gradually declines at 10-15 years of age (14). Figure 2.2 demonstrates the critical period of brain development.

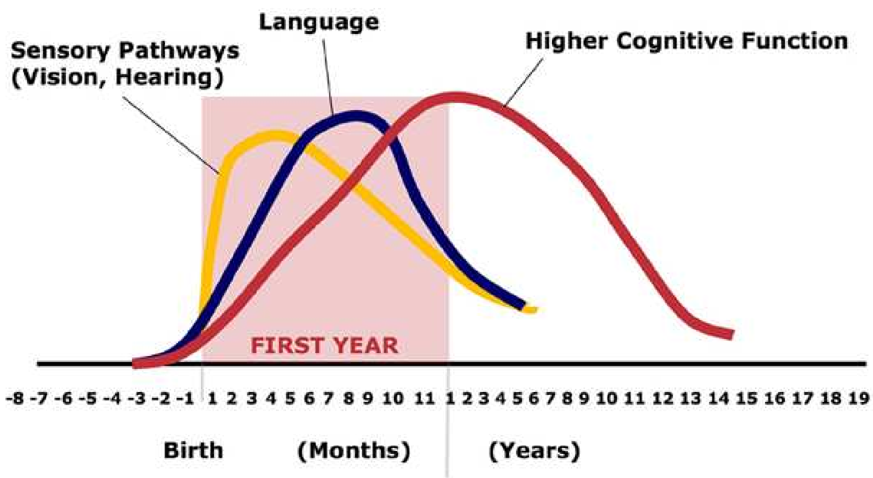

Figure 2.2 Human brain development

This figure shows the development of brain. The yellow line shows the sensory development period and more fully development after birth until 6 months. The blue line shows the language development period and more fully development in the range of 6 months to 1 year. The red line shows higher cognitive function development period and more fully development in the range of 1-6 years though the neural density of the frontal lobes begins to decline at 7-14 years of age (14).

Visual Motor Integration task depends on the maturation and integration of perceptual-motor skills, plays an important role in mental representation of motion, which have been linked to motor planning and the development of motor skills in general (21). The ability of visual motor integration is the visual perception, the process responsible for the reception and cognition of visual stimuli, and finger-hand movements are well coordinated (22, 23). Shumway-Cook and Woollacott. (2002) found that the Visual-Motor Integration contains sensory processes, including visual perception and motor processes, and motor coordination (10). All of these advanced developments have occurred from infancy to adolescence. Previous studies revealed the most rapid growth or the critical period of the VMI begins to occur during children age at 5-6 years old (5, 6) the more developed has found at age of 7-9 years old. Taylor Kulp M (1999) found that the Visual-Motor Integration was significantly correlated with only reading achievement rating in 7-year old, but the Visual-Motor Integration was significantly correlated with reading, writing, spelling, and math achievement rating in 8-, and 9-year olds, but in the 5-, 6-years old. Thus, the rating of achievements is not so precise as the kindergarten children as they were in other grades (53). This could be concluded that the core development of Visual-Motor Integration starts from infancy to age of 5-6 years when Visual-Motor Integration reaches the full development. The previous studies supported that the children aged between 7-9 years would have the advanced development of Visual-Motor Integration. It was obvious that the children aged 7 years old would have the development so close to adults while the children aged 8-9 years old had the same development of Visual-Motor Integration like adults.

Visual-Motor Integration requires the normal executive function, an ability to transform visual inputs into movement plans (10). The cognitive processes are the components of executive function. The prefrontal cortex plays a major role in the processes of executive function, cognitive control, memory and inhibition behavior. Executive function is functioning in the frontal lobe areas and prefrontal cortex. It was found that this area controls the abilities in planning and organization, control and shifting, working memory, problem solving, abstract thinking, response inhibition, and reasoning. Based on the research in neuroscience, Figure 2.2 demonstrates the executive brain functions by Gilbert et al. (2006). It shows none of the coordinates of these executive and memory functions are located in the medial prefrontal cortex, except for a small part of the multitasking and attention studies that tend to be located at a frontal part of the medial prefrontal cortex, and extend to the lateral prefrontal cortex (26).

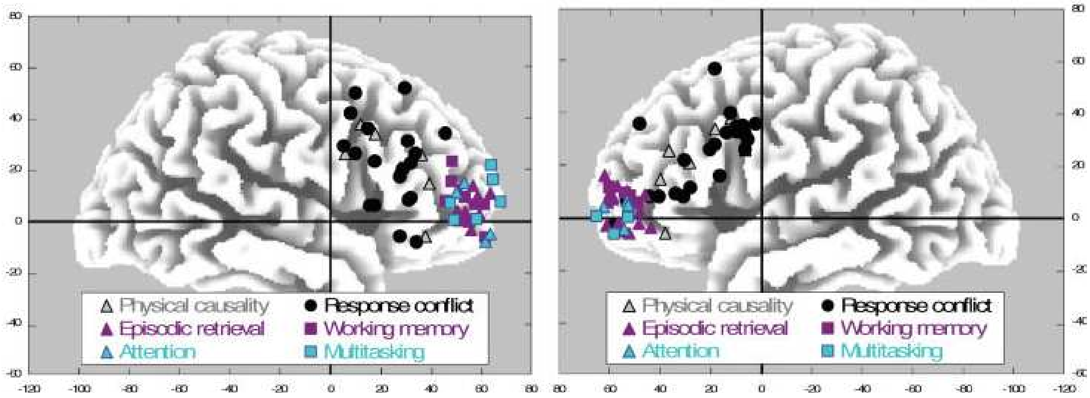

Figure 2.3 The lateral prefrontal cortex

This figure shows the development of the lateral prefrontal cortex. The spots show the lateral prefrontal cortex involved in causal learning and executive functions, right and left lateral view. Black spots response to conflicts and physical causality, which are found most at the lateral border area in prefrontal cortex. The blue and violet spots relate to attention, multitasking, episodic retrieval, and working memory, which are most found at anteromedial area in prefrontal cortex (26).

Executive function develops during the ages of 2 to 5 years with dramatic increases of neuronal growth in dorsolateral prefrontal cortex and it is mature later in adolescence. Development of executive function, children's working memory and inhibitory control had significantly increased by ages. Children start to display performance of the executive function, usually between 3 to 5 years (13, 27). During early childhood, from 5 to 7 years, it is particularly an essential milestone for memory and inhibition (28). Nevertheless, preschool children do not have the full maturity of executive function until children reach the ages of 8 to 9 years. They display major increases in verbal working memory and response inhibition, and then, after the age of 10 years or pre-adolescent, the synaptic begins pruning, and it makes a change of executive function, especially working memory and inhibitory control (14, 15).

Working memory refers to a brain system that provides temporary storage and manipulation of information necessary for cognitive tasks such as understanding complex language, learning, and reasoning (29). For school-aged children, the functioning of working memory is the center of the executive function because children use the working memory for thinking and learning (28). For example, working memory focuses on how learners actively manage their information and memory to learn. Strong working memory can be improved with attention and previous experiences in order to build a strong memory and strategies that promote learning simultaneous processing of information (30). According to previous research in working memory, some studies found the positive correlations with the components of working memory and school achievements. For example, the researchers found that working memory relates to the components of school achievement, including writing, reading, and mathematics skill (3). The research that was conducted by Anderson RJ. (1995) found that children's working memory and their ability in school subjects were significantly correlated (31). The findings indicated that working memory is associated with school achievements.

Inhibitory control is a key component of the executive function. Inhibitory control is a selective attention and control behavior (32). For school-aged children, inhibitory control enables the children to control their impulses and think before acting based on the guided behaviors and setting limits. According to previous research in inhibitory control, it was positively correlated with the components of inhibitory control and externalizing behavior. For example, the result from the research conducted by Gerstadt, Hong, & Diamond (1994) found that children's inhibitory control and their ability to regulate externalizing behavior were significantly correlated (33). Specifically, the emotion regulation plays an important role in inhibitory control (34). In conclusion, regarding the key development of executive function in childhood, the executive function will be continuously developed and it is on peak at the age of 6 years. At the age of 7 years, the development of working memory and inhibitory control will start, and these will be greatly developed between 8-9 years old. But, after the age of 10 years, the brain pruning will re-occur. The change of executive function, especially working memory and inhibitory control, will appear.

Previous studies have shown that VMI subscales composed of visual perception and motor coordination (23), and working memory and inhibitory control subscales are attention (8), speed (35), and accuracy (36). The next section described the research in the subscales of visual-motor integration, working memory and inhibitory control.

2.2 The subscales of VMI, working memory, and inhibitory control

VMI is the ability to perceive visually translated into motor and related motor control, motor accuracy, motor coordination, and mental speed (35), that causes coordination. For example, the result from the research conducted by Teresa Farroni and Enrica Menon, 2008 found that the Visual-Motor Integration contains visual perception and motor coordination, perceived mobility and function of fingers visible coordination (24). This study is consistent with Frostig, M., D. W. Lefever, et al., 1961 who found that important components of the VMI are the visual perception and motor coordination (37). As mentioned above, VMI consists of 2 components. First, visual perception is the ability to interpret the environment by processing information contained in invisible light perception, which is known as the sight or vision (38). School-aged children requires the integration of all part of the body's sensory experiences for school readiness. Because vision and motor were required for approximately 75% of learners in classroom. The children with weak vision represented to struggle with learning in the classroom and throughout the life span (20, 37). Second, motor coordination is an ability to control the body, and coordinate the implementation of eyes and hands for manipulative movements (38). Motor coordination emerging during the school age provides a substantial part of the motor skill foundation upon which more complex motor programs are formed, and motor coordination is gradually processed by which school-age children use and develop their strength, posture control, balance, and perceptual skill (7, 39). Both Visual perception and motor coordination are referred to VMI. In school-age children, VMI including visual perception and motor coordination are important for children's learning skills, especially handwriting skills. Handwriting skill is one of most support learning skills in the elementary years. Children need visual perception for processing their visual information. They need motor coordination for organizing and remembering information to control hands for writing (4).Visual perception and motor coordination require the executive function in normal cognition to transform visual inputs into action movement. Executive function is responsible for maintaining the stimulus and response action plan (10, 11).

Executive function is a higher-order cognitive process carried out by prefrontal areas of the frontal lobe. Children use it to control activities such as plan and organization, working memory, inhibition, emotional control, and shifting. Working memory and inhibitory control is center of executive function (28). Working memory and inhibitory control are the elements that children used to learn on a daily basis. Many studies found subscales of working memory and inhibitory control that made working memory and inhibitory control strong. Baddeley, 1986, found that the attention was necessary for manipulating information in working memory of human cognitive capacities (29). This study was consistent with Daryl Fougniev, 2008, who found that attention authorized the processing efficiency of new data during multi-stages of processing including early sensory and post perceptual processes. At the same time, working memory can be functionally dissociated, depending on the type of data to be stored in the system. (8). Furthermore, speed and accuracy are the subscales of working memory. In 2008, Nash Unsworth and Randall W. Engle conducted the research designed to evaluate speed and accuracy of accessing information in working memory (36) The results showed that the individual differences in short-term or working memory were correlated with speed. This research was consistent with the study of Astrid F. Fry, Sandra Hale, 2000, who examined the association among processing speed and working memory. They found that speed information processing was correlated with working memory, and it was different at each different age. Information speed processing in working memory of young adults was higher than children. The different speed for information coding in memory span could largely be explained by age-related in processing speed (35).

In addition, the result from the research conducted by Carin C.E., 2002, found that the attention is important to help children inhibit themselves (40). This study examined children attention with deficit hyperactivity disorder. The results showed children with lower attention were correlated with lower emotional and motor inhibition. In the previous research as mentioned above, it suggested that the attention was considered as one subscale that helped organize the information and maintain the working memory and inhibitory control. Furthermore, speed and accuracy were the subscales of Inhibitory control. In 1997, Ridderinkhof KR conducted research on the relationship between speed and accuracy and ages and performance of inhibition. The results showed that the ages and performance of inhibition related changes in processing speed and accuracy in children (41).

In summary, VMI and executive function are necessary to children, especially school-aged children as they are windows of opportunity for developing. Subscales are most important to function synergistically for VMI and executive function, particularly working memory and inhibitory control works well. From the previous research, it can be concluded that the subscales of VMI are visual perception and motor coordination (37, 38), and subscales of the working memory and inhibitory control are attention, speed, and accuracy (35, 41). Therefore, each assessment subscale to view the performance of visual-motor integration and working memory and inhibitory control is important and necessary for school-aged children. Next section would describe the instrument for measuring visual-motor integration and executive function in school-aged children.

2.3 The instrument for measuring VMI and executive function in school-aged children

There are many research studies used to evaluate visual-motor integration. For example, Mei Hui Tseng and Susanna M. K. Chow, 2000, used Visual-Perceptual Skills (TVPS) for assessing visual-perceptual strengths and weaknesses on handwriting skills in 35 school-aged children. The finding suggested that TVPS could assess the performance of children's visual memory, visual sequential memory, and sustained attention, but this tool did not focus on motor coordination and visual-motor integration in any previous research. A limitation of the research on the use of this tool was that the children wanted good receptive language skills to complete the assessment (42). In addition**,** Po Wah Chan, 2000, studied the association between visual and motor and academic performance in 748 children in middle class, 4 to 8 years from Hong Kong, who were given the Bender-Gestalt test. A limitation of the research on the use of this test was that it measured children's visual motor development rather than the visual and motor integration (43). Moreover, the Beery-Buktenica Developmental Test of Visual-Motor Integration, Sixth Edition, the BEERY™ VMI is one of the most important tasks for measuring the visual-motor integration. It assesses whether or not the children can integrate their visual and motor abilities. Jitpanut Makchoay (2010) examined the association between musical expertise and visual-motor integration given by VMI. The result showed that the development of visual-motor integration were correlated with learning skills for children applied in their daily activities (44). The advantage of this tool is commonly used to identify children who have the significant difficulty in visual-motor integration.

Table 2.1 Test Overview: Major Performance Domains Assessed by Each test

Tools	Assessment of visual skill	Assessment of motor skill	Assessment of visual-motor integration skill	Age range tested
Visual-Perceptual Skills (TVPS)	✓	-	-	4-18 years
Bender-Gestalt test	✓	✓	-	4-85 years
BEERY™ VMI	✓	✓	✓	2-100 years

Several instruments were used to evaluate the executive function in school-aged children such as working memory, inhibition, plan and organization, shifting, and emotional control. For example, Marilyn C. Welsh, 1991, assessed the normative-developmental of executive function in school-aged children. The measurement was developed from clinical neuropsychology used by Wisconsin Card Sorting Task (WCST) to assess perseveration and abstract reasoning, and used by Tower of Hanoi (TOH) to evaluate the executive planning. The result showed that the children aged 6-10 years had the performance of executive function similar to adults (45). In addition, Seidman LJ et al., 1995 used Rey-Osterrieth Complex Figure (ROCF) to assess performance of 65 school-aged boys with ADHD. The ROCF can be used to evaluate visuospatial abilities, memory, attention, planning, and working memory. The result showed that the performance of working memory and planning were necessary to assess the school-aged children. Specifically, the learning of children with ADHD could be observed (46). Moreover, Task of Executive Control (TEC) is computer task used to measure working memory and inhibitory control (47). Krivitzky LS., 2011 applied the Task of Executive Control (TEC) to assess working memory and response inhibition in children with mild traumatic brain injury. The result showed the performance of working memory and inhibitory control of these children were similar to normal children (50).

Table 2.2 Test Overview: Major Performance Domains Assessed by Each test

Tools	Plan and organization	Shifting	Working memory	Inhibition	Age range tested
Wisconsin Card Sorting Task (WCST)	✓	✓	-	-	7-89 years
Tower of Hanoi (TOH)	✓	✓	✓	-	7-15 years
Rey-Osterrieth Complex Figure (ROCF)	✓	-	✓	-	6-89 years
Task of Executive Control (TEC)	-	-	✓	✓	5-18 years

The previous study showed that VMI had strong correlations with many instruments. For example, Michael J. Breen., 1985, found that VMI was correlated with WISC-R, and Bender Gestalt (51). In addition, Beery, K.E., & Beery NA., 2004, found that VMI was correlated with WISC-R (Revised Wechsler Intelligence Scale for Children), DTVP-2 (Developmental Test of Visual Perception), WRAVMA (Wide Range Assessment of Visual Motor Abilities), Visual Motor test, and CTBS (Comprehensive Test of Basic Skills) (1), but no one has studied the correlation with TEC. Several studies investigated correlations between TEC and other instruments. Peter K. Isquith, Robert M. Roth, and Gerard A. Gioia, 2007, found that TEC was correlated with WISC-R (Revised Wechsler Intelligence Scale for Children), CPRS-R:L

(The Conners' Parent Rating Scales-Revised Ling Form), CBCL (The Child Behavior Checklist), PCSI (Parents and teachers and developmentally specific self-report forms), ESS (Everyday Situation Survey), FAD (Family Assessment Device), and Performance-Based Neuropsychological Measures, respectively (52). Interesting, no studies investigated the correlation with VMI. Human development must go on step by step. Visual-Motor Integration is one of developmental basis to reach the strong executive function. Thus, the present study aimed to examine correlations between VMI and TEC.

In conclusion, all of above mention that Visual-Motor Integration is fully developed at ages between 7to 9 years old. At 7 years old, the development of VMI will be close to adults. At 8 to 9 years, the children's VMI is not different from adults. Regarding the important development of executive function, children at 7 years old will develop their working memory and inhibitory control. The great development occurs at the age of 8 to 9 years. However, after 10 years old, the pruning in brain will re-occur. There will be some changes in the executive function, especially working memory and inhibitory control.

According to review of the literature, the children at 6 years old and under have not yet acquired the completed development of Visual-Motor Integration, working memory and inhibitory control. After 10 years, when the children enter into pre-adolescence, their brain will have the pruning again. They will have some changes in the Executive Function, especially working memory and inhibitory control. Therefore, this study aimed to study children at aged between 7 to 9 years old. Instruments used to measure and assess the Visual-Motor Integration and Executive Function covering ages in this study were VMI and TEC. There were some studies examining the relationship between VMI and visual and motor performance assessment instruments. There were some studies examining the relationship between TEC and cognitive measurement instruments. Hence, we found some important gaps. If considering the development, Visual-Motor Integration was the basis to the development of Executive Function, but no studies were conducted to examine the relationship of both instruments or between VMI and TEC. Therefore, this study aimed at investigating the relationship between VMI and TEC in school-aged children at ages of 7-9 years.

Next chapter describes the research design, research questions and hypotheses as well as research methods and procedures. The chapter ends with the research analysis.

CHAPTER III
METHODOLOGY

3.1 Introduction

This chapter contains the research methodology and procedures of this research. The topics are as follows: research questions and hypotheses, population, variables, measurement, data collection, ethical issues and data analysis.

3.2 Research Question and Hypotheses

The research question of this study was:

- Are there any statistically significant correlations between each subscale of Visual-Motor Integration, as measured by Visual-Motor Integration (VMI) and each subscale of Executive Control, as measured by Task of Executive Control (TEC) in school-aged children?

The hypotheses of this study are;

- H_0: There are not any statistically significant correlations between the subscale of Visual-Motor Integration as measured by Visual-Motor Integration (VMI) and the subscale of Executive Control as measured by Task of Executive Control (TEC) in school-aged children.

- H_1: There are some any statistically significant correlations between the subscale of Visual-Motor Integration as measured by Visual-Motor Integration (VMI) and the subscale of Executive Control as measured by Task of Executive Control (TEC) in school-aged children.

3.3 Population and Sample Group

3.3.1 Population of the research

The population of this study was the primary school children aged between 7-9 years studying in the educational year of 2013 under the Nakhonratchsima Education Service Area Office in Thailand.

3.3.2 Sample group

The sample groups of this research were 123 primary school children at ages of 7-9 who were studying in schools, in the educational year of 2013 under the Nakhonratchsima Education Service Area Office. The sample group was selected by the Multistage Random Sampling as per the following steps:

3.3.2.1 Thailand consists of 6 regions. One of six regions was selected by the simple random sampling. The northeastern region was selected.

3.3.2.2 The northeastern region consists of 20 provinces. One of twenty provinces was selected by the simple random sampling. Nakhonratchasima province was selected.

3.3.2.3 Nakhonratchasima Province consists of 7 education regions. One of seven regions was selected by the simple random sampling. The Education Service Area Office, Region7 was selected.

3.3.2.4 The researcher utilized the systematic random sampling to select certain participating schools by sending e-mail messages and making phone calls to 228 primary schools in the list of primary schools in the Education Service Area Office, Region7. The sample primary schools were those agreed to participate in this study (i.e., Bantoeykraton School). Thus, the sample of study consisted of 123 school-aged children aged between seven to nine years-old who enrolled in primary schools in May 2013.

3.3.2.5 The sample size of this study was based on the sample size principle suggested by Fleiss J (1973) who recommended the sample of 100-120 cases. For correlations purpose, the number of samples should not be less than 80 cases, depending on research design. Therefore, the sample size of the study met the requirement. (48).

There were the inclusion and exclusion criteria for the sample group. The factors affecting visual-motor integration and executive control were evaluated to control confounding variables. Therefore questionnaire was developed for evaluate the inclusion and exclusion criteria as follows:

Inclusion criteria

Parents

- The parents answered the questionnaires and showed their agreement in consent forms signed by them.

School-aged children

- Students at ages of 7-9 who were studying in schools in the educational year of 2013.
- Gender: Boys and Girls.
- Agreed to participate in this study and their parents signed the consent forms.

Exclusion criteria

Parents

- The parents answered the questionnaires and disagreed to sign the consent forms.

School-aged children

- Having cognitive difficulties or attention problem, which were diagnosed by neurological specialists
- Physical impairments
- Learning Disabilities included agraphia.
- Visual Impairments included color blindness and strabismus.
- Disagreed to participate in this study and their parents did not sign the consent forms.

3.4 Instruments

In this research, a questionnaire and 2 standardized instruments were applied:

3.4.1 Questionnaire

The questionnaire was completed by the school-aged children's parents for general information about parents and children:

- Part 1: Parents: this involved the family background comprising 8 items including caregivers, status of parents, parents' level of education, parents' career and average monthly family income, parents-children relationship, number of children and total family members.
- Part 2: School-aged children: this part was gather information of children background comprising 21 items including gender, age, level of education, health background, nutrition, activities of fine motor and visual perception at school and home, favorite activities, frequency of playing toys beneficial to fine motor development, duration of plays each time, frequency of playing computer games and activities, duration of playing computer game each time, frequency of doing activities with the parents and duration in each activity, activities of the children done at home.

3.4.2 Standardized Instruments

3.4.2.1 The Beery-Buktenica Developmental Test of Visual-Motor Integration (VMI) 6^{th}edition

Figure 3.1 The Beery-Buktenica Developmental Test of Visual-Motor Integration (VMI) 6^{th}edition

The Beery-Buktenica Developmental Test of Visual-Motor Integration (VMI) assesses the extent to which individuals can integrate their visual and motor abilities (eye-hand coordination), The *Beery* VMI can be validly administered as either a group screening test or for individual assessment purposes with children at age of 2 up to adult 100 years of age. There are two supplemental standardized tests, Visual Perception and Motor coordination. The Beery-Buktenica Developmental Test of VMI is accepted for its internal, interjudge and test-retest reliability. The *Beery* VMI provides such reliabilities at high levels. In terms of validity, the *Beery* VMI measures up at very high levels between .80 and .95.

- **The *Beery* VMI** is a developmental sequence of geometric forms to be imitated or copied with paper and pencil. The *30-item Beery* VMI Full Form for ages 2 through 100 can be in group or individually administered in 10-15 minutes. The 21-item Short Form is available for ages 2 through 7.This form is usually administered individually in less than 10 minutes. The *Beery* VMI is designed to assess the extent to which individuals can integrate their visual and motor abilities. If a child performs poorly on the *Beery* VMI, it could be because he or she has adequate visual-perceptual and/or motor coordination abilities. Scoring of the *Beery* VMI is one point for each imitated or copied item up to three consecutive failures. To obtain a raw score, the number of items that are not successfully completed prior to this ceiling of three consecutive failures is subtracted from the ceiling. These scoring criteria and procedures apply to both *Beery* VMI test forms, the Full and Short forms. Scoring of the *Beery* VMI is one point for each imitated or copied item up to three consecutive failures. To obtain a raw score, the number of items that are not successfully completed prior to this ceiling of three consecutive failures is subtracted from the ceiling. These scoring criteria and procedures apply to both *Beery* VMI test forms, the Full and Short forms.

- **Visual Perception** test: the first three items require very young children to identify parts of their own bodies, picture outlines, and parts of a picture. For the remaining 27 items, one geometric form that is the same as each stimulus is to be chosen from among others that are not exactly the same as the stimulus. During a three-minute period, the task is to identify the exact match for any of the 27 stimuli as possible. Scoring of the Visual Perception, just one point is awarded for each correct item until three consecutive incorrect items are scored or the 3-minute time limit expires.

- **Motor coordination** test: the first three items require very young children to climb on the chair, hold a pencil with their thumb and fingers, and hold the paper as they mark it. For the remaining 27 items, the task is to simply trace the stimulus forms with a pencil without going outside double-lined paths. The Motor Coordination test takes about 5 minutes to administer. An item is scored one point if meets all three of the following criteria (a.) There are pencil marks within all parts of the roads and between all dots and the marks do not have to be complete. (b.) No mark clearly goes over a road line. And (c.) There must be at overlap and one over/ underlap.

Scoring of the VMI is essential, one point for each imitated or copied item up to three consecutive failures. To obtain a raw score, the number of items that are not successfully completed prior to this ceiling of three consecutive failures is subtracted from the ceiling. Scores are then summed within each task. The high scores indicate greater visual-motor integration, and the poor scores mean children who need appropriate intervention to help integrate their visual and motor abilities. VMI scoring is based on Score and No Score criteria. The criteria of VMI scores were shown in Appendix. For score interpretation for data analysis, the test involves 3 sets. The first VIM set involves 30 items with 30 scores. The second set is the visual perception comprising 30 items with 30 scores. The third set is the motor coordination comprising 30 items with 30 scores. The test scores were the children's raw scores, which will be compared as standard scores. Then, such standard scores will be compared to be scale scores to be used in the statistical correlation analysis. Scale scores are used for the SPSS analysis. Scale scores are divided into 3 ranges: Range "1" means "above average. Range "2" means "average". Range "3" means "below average". Here, if the children are in the same range; this means that they have no different abilities, as describe in table 3.1.

Table 3.1 This table contains the information VMI, Visual perception and Motor coordination scores

Instrument/scores	standard scores	scale scores	range
VMI	123-155+	15-20+	"1" represents "above average"
Visual perception	78-122	6-14	"2" represents "average"
Motor coordination	45-77	-1-5	"3" represents "below average"

3.4.2.2 Task of Executive Control (TEC)

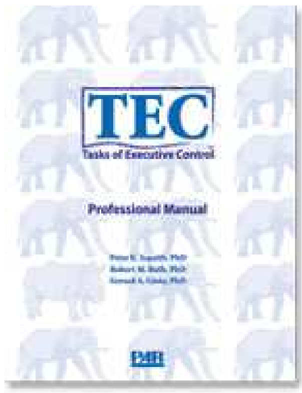

Figure 3.2 The Task of Executive Control (TEC)

The Task of Executive Control (TEC) is standardized as computer-administered measure of working memory and inhibitory control. It is designed for children and adolescents between ages of 5 and 18 years, including those with a wide variety of development and neurological disorders. An N-Back paradigm that parametrically increases working memory load and a go/no-go task to manipulate inhibitory control demand. This combination of methods yields four sequential tasks for 5 to 7 year old children and six tasks for older children and adolescents.

- **N-Back** task is widely used with adults and children to evaluate working memory. In this paradigm, an individual is presented with a series of stimuli, one stimuli at a time and press a particular button each time he or she sees a frequent, or standard, stimulus but a different button when he or she sees an infrequent, or target, stimulus. Separate 0-back, 1-back, 2-backc conditions often are administered, increase with age.

- **Go/No-Go** task is a relatively simple measure of inhibitory control that presents go and no go stimuli serially overtime. The go stimuli require a rapid motor response, he or she pressing a button on the keyboard. In contrast, responding must be withheld, or inhibited, when the no-go stimulus appears. In the TEC, the no-go is a box surrounding any pictured object, he or she are not to respond when the box is present.

TEC score available for typically developing children were subjected to principal factor analysis with oblique rotation, yielding a three factor for the 5 to 18 year-old-age. Factor analyses and calculation of factor scores are TEC software for saving or modifying reports, and printing reports.

The TEC calculates multiple performance accuracy, speed, and attention scores within each task condition (Task scores) and across the instrument as a whole (Factor and Summary scores) that are compared to normative values. Scores are then summed within each tasks presented individual's performance as working memory load and inhibitory control demand. The scores interpreted by the Program might be divided into ranges, and each range was represented for the SPSS computation. This also means that the children in the same range would have no different abilities, as describe in table 3.2.

Table 3.2 This table explains the factor and range of TEC evaluation

Factors/Range	Elevated = "1"	Typical = "2"	Below = "3"
Accuracy	61-100	41-60	1-40
Attention	61-100	41-60	1-40
Speed	61-100	41-60	1-40

3.5 Data collection

3.5.1 The letter was sent to the Faculty of Graduate Studies to get a Letter of Recommendation and permission for data collection. Then, the letter of recommendation and permission for data collection was submitted to school directors of targeted schools of this research. The letter indicated objectives, expected benefits and data collection process of this research. Then, the Researcher contacted those schools, introduced herself and explained objectives, expected benefits and data collection process of this research to directors of the targeted schools again.

3.5.2 Meet the parent's subjects and introduced herself to parents, explained the research objectives and asked for participation in research data collection including the subject's protection in affirmation of rejection of the request to participate in this research.

3.5.3 The consent forms, questionnaires, The *Beery* VMI 6th edition, and The Task of Executive Control (TEC) were distributed to the students' parents who signed consent forms, which had to be completed within 2 days, and screened subjects by using questionnaires (parents answered the questionnaires). Screening subjects was completed within 1 day.

3.5.4 Questionnaires, The *Beery* VMI 6th edition, and The Task of Executive Control (TEC) were completed within 2 weeks.

3.5.5 These scores were analyzed by using descriptive statistics and correlation.

3.5.6 The results and discussion were written by November 2013

Table 3.3 This table represents the time of research period (TOR)

PLAN	April-May	June-july	August	September-November	December	January-March	17-Apr
Literature review	■						
Progress proposal/proposal examination		■	■				
Ethic				■			
Try out TEC & VMI				■			
Test TEC & VMI				■			
Analyse data					■		
Progress proposal/prepare manuscript					■		
Submit manuscript					■		
Thesis writing						■	
Thesis examination							■

3.6 Data Analysis

In this research, the statistic computer program was applied to analyze the obtained data. Both descriptive and inferential methods were employed. The descriptive statistics (mean and Standard Deviation) were utilized to explain the sample's background characteristics whereas the inferential methods were performed by using bivariate-correlation to investigate the significant correlations among the subscales of Visual-Motor Integration (VMI) and Task of Executive Control (TEC).

3.7 Ethics

This research proposal was approved by the Committee on Human Rights Research Involving Human subjects of the Mahidol University. The participants were approached and asked to participate in this research. The researcher explained the objectives, method, instruments and expected benefits of this research to participants. The protection of human rights was given to the participants and indicated their willingness to participate by signing a consent form. The participants could ask for any additional information and could stop or withdraw from this study at any time without any effect.

Next chapter will present the data analysis results. Tables relating to those results will be also demonstrate and explain. The results conclusion of this current study will appear at the summarize section at the end of the next chapter.

CHAPTER IV
RESULTS

This study examined the significant correlations of each subscale of Visual-Motor Integration, as measured by the Visual-Motor Integration (VMI) and each subscale of Executive Control, as measured by the Task of Executive Control (TEC) in school aged children

This chapter presents the results of the study, which is divided into 2 sections. First section describes the demographic data and background of the sample (see appendix: Questionnaires). The results of the analysis, using descriptive statistics, present the mean, and frequency of the demographic data and background. Next, second section includes 2 subsections. Each subsection presents the results of the analyses focusing on the significant correlation between the subscales of children's visual-motor integration, as measured by the VMI and the subscales of children's executive function, as measured by TEC.

4.1 Section I: Results of descriptive statistic analysis for the demographic data and background of the sample

In this section, descriptive statistic analysis is explained in three dimensions; including family background, child background, and child activities and school age children background. The sample of this study is selected by using the multistage random sampling represented the population in Prathai district, Nakornratchasima. The total sample was 123 children school aged from Bantaoykraton School in Prathai district, Nakornratchasima.

First dimension is family background describing the demographic data and background of the parent sample, relationship with the child, who raises the child, number of family members, father's level of education, mother's level of education, parent's level of education, father's career, mother's career, parent's career, and family income. **For the 7-year-old** (N=39), The results showed in Table 4.1.For relationship with the child 59% of the sample was mother, 38.5% was father, and 2.5% was aunts. For the main caregiver, approximately 35.9% of the parents were the father and mother of the participants. For the parent's educational degree, the fathers of the sample had educational degree senior high school degree for 38.5%, elementary education degree for 30.8%, junior high school degree for 28.2%, and bachelor degree for 2.6%. The mothers of the sample had educational degree junior high school degree for 35.9%, elementary education degree for 33.3%, and senior high school degree for 30.8%. For the parent's career, the results showed that the fathers of the sample had freelance for 76.9%, own business for 12.8%, and private employee for 7.7%. The mothers of the sample had freelance for 46.2%, own business for 30.8% and being house wife for 15.4%. The majority of the sample group (74.4%) earned monthly income in the range of <10,000 baths, while 25.6% earned monthly income in the range of 10,001-20,000 baths.

Table 4.1 Number and Percentage of demographic characteristic of school age children 7 years (N=39)

General Characteristic	Number (%) N = 39
Administer	
Mother	23 (59)
Father	15 (38.5)
Aunts	1 (2.5)
Total	39 (100)
Father's level education	
Elementary education degree	12 (30.8)
junior high school degree	11 (28.2)
Senior high school degree	15 (38.5)
Bachelor degree	1 (2.6)
Total	39 (100)

Table 4.1 Number and Percentage of demographic characteristic of school age children 7 years (N=39) (cont.)

General Characteristic	Number (%) N = 39
Mother's level education	
Elementary education degree	13 (33.3)
junior high school degree	14 (35.9)
Senior high school degree	12 (30.8)
Total	39 (100)
Father's career	
Freelance	30 (76.9)
Own business	5 (12.8)
Private employee	3 (7.7)
Etc.	1 (2.6)
Total	39 (100)
Mother's career	
Freelance	18 (46.2)
Own business	12 (30.8)
House wife	6 (15.4)
Private employee	3 (7.7)
Total	39 (100)
Family income (bath per month)	
< 10,000	29 (74.4)
10,001 – 20,000	10 (25.6)
Total	39 (100)

For the 8 to 9-year-old (N=84). The results showed in Table 4.2. For relationship with the child 60.7% of the sample was mother, 26.2% was father, and 7.3% was grandparents. For the main caregiver, approximately 36.6% of the parents were the father and mother of the participants. For the parent's educational degree, the fathers of the sample had educational degree elementary education degree for 64.3%, junior high school degree for 16.7%, and junior high school degree for 16.7%. The mothers of the sample had educational degree elementary education degree for 66.7%, junior high school degree for 15.5%, and senior high school degree for 17.9%. For the parent's career, the results showed that the fathers of the sample had freelance for 66.7%, private employee for 11.9%. The mothers of the sample had freelance for 66.7%, own business for 17.9% and being house wife for 17.9%. The majority of the sample group (50%) earned monthly income in the range of <10,000 baths, while 40.5% earned monthly income in the range of 10,001-20,000.

Table 4.2 Number and Percentage of demographic characteristic of school age children 8 to 9 years (N=84)

General Characteristic	Number (%) N = 84
Administer	
Father	22 (26.2)
Mother	51 (60.7)
Grandparents	9 (10.7)
Aunts	2 (2.4)
Total	84 (100)
Father's level education	
Elementary education degree	54 (64.3)
junior high school degree	16 (16.7)
Senior high school degree	16 (16.7)
Bachelor degree	2 (2.4)
Total	84 (100)

Table 4.2 Number and Percentage of demographic characteristic of school age children 8 to 9 years (N=84) (cont.)

General Characteristic	Number (%) N = 84
Mother's level education	
Elementary education degree	56 (66.7)
junior high school degree	13 (15.5)
Senior high school degree	15 (17.9)
Total	84 (100)
Father's career	
Government officer	3 (3.6)
State owned enterprise	2 (2.4)
Government employee	3 (3.6)
Freelance	56 (66.7)
Own business	3 (3.6)
Farmer	3 (3.6)
Fisherman	1 (1.2)
Private employee	10 (11.9)
House husband	2 (2.4)
Etc.	1 (1.2)
Total	84 (100)
Mother's career	
Government officer	1 (1.2)
Government employee	2 (2.4)
Freelance	40 (47.6)
Own business	15 (17.9)
Farmer	4 (4.8)
Private employee	7 (8.3)
House wife	15 (17.9)
Total	84 (100)

Table 4.2 Number and Percentage of demographic characteristic of school age children 8 to 9 years (N=84) (cont.)

General Characteristic	Number (%) N = 84
Family income (bath per month)	
< 10,000	42 (50.0)
10,001 – 20,000	34 (40.5)
20,001 – 30,000	5 (6.0)
30,001 – 40,000	2 (2.4)
40,001 – 50,000	1 (1.2)
Total	84 (100)

The second dimension is child background describing gender, age, grade, underlying disease, disability, eyesight, movement, balance, learning, behavior, health, seizure, accident, time use for sleeping, for example. In this dimension, the results of the disorder showed that most of the 7-year-old sample (N = 39) did not have any physical abnormal, disorder of Cognitive difficulties attention problems, which diagnosed by neurological specialists, and was not extracurricular learning such as sports or arts. For disability, 94.9% and over of the sample does not have disability, seizure, accident, time use for sleeping, but has normal eyesight, movement, balance, learning, behavior, and has healthy. However, the result also showed that some background variable of the sample were difference (see table 4.3). Table 4.3 showed that 64.1% of the sample is boys and 35.9% is girls. 100% of the simple is 7.0-7.11 years old. 5.1% of the sample had underlying disease. 46.2% of sample has lower 10 hours/days sleeping at night, and 53.8% of sample has 10 hours and over sleeping at night per day. Based on previous research, the results have suggested that age and gender may have an effected on cognitive development. Therefore, gender and age were applied as covariates in order to covariate out these confound variables in this study.

Table 4.3 Children background of 7 years old

General Characteristic	Number (%) N = 39
Gender	
Male	25 (64.1)
Female	14 (35.9)
Total	39 (100)
Age	
7.0 -7.11 years	39 (100)
Total	39 (100)
Underlying disease	
Yes	2 (5.1)
No	37 (94.9)
Total	39 (100)
Time use for sleeping (hours sleeping at night per day)	
< 10	18 (46.2)
≥ 10	21 (53.8)
Total	39 (100)

For school-aged children 8 to 9 years background (N = 84). In this dimension, the results of the disorder showed that most of the sample did not have any physical abnormal, disorder of Cognitive difficulties attention problems, which diagnosed by neurological specialists, and was not extracurricular learning such as sports or arts. For disability, 94% and over of the sample does not have disability, seizure, accident, time use for sleeping, but has normal eyesight, movement, balance, learning, behavior, and has healthy. However, the result also showed that some background variable of the sample were difference (see table 4.4). Table 4.4 showed that 51.2% of the sample is boys and 48.8% is girls. 46.4% of the simple is 8.0-8.11 years old, and 53.6% of the simple is 9.0-9.11 years old. 6% of the sample had underlying disease. 38.1% of sample has lower 10 hours/days sleeping at night, and 61.9% of sample has 10 hours and over sleeping at night per day. Based on previous research, the results have suggested that age and gender may have an effect on cognitive development. Therefore, gender and age were used as covariates in order to covariate out these confound variables in this study.

Table 4.4 Children background of 8 to 9 years old

General Characteristic	Number (%) N = 84
Gender	
Male	43 (51.2)
Female	41 (48.8)
Total	84 (100)
Age	
8.0 -8.11 years	39 (46.4)
9.0 -9.11 years	45 (53.6)
Total	84 (100)
Underlying disease	
Yes	5 (6.0)
No	79 (94.0)
Total	84 (100)
Time use for sleeping (hours sleeping at night per day)	
< 10	32 (38.1)
≥ 10	52 (61.9)
Total	84 (100)

Third dimension is the child activities describing art, academic activity, sport activity, activity at home, watching television, playing computer game, and the most frequent activities of children. **For 7-year-old** the results of activities showed that 38.5% of the sample did housework activities, 33.3% played with friends activities, 12.8% did cycling activities, and 10.2% did homework activities. For sample watching television and playing computer game, 97.4% of the sample watching television, and 71.8% playing computer game. 63.1% of the sample watching television, and 71.8% playing computer game. 63.1% of the sample watches television 1-2 hours per week, 13.2% for 4 hours and over per week, and 10.5% for 1 hours and lower per week. 60.7% of the sample playing computer game for 1-2 hours per week, 25% for 1 hours and lower per week, and 10.7% for 2-3 hours per week.

Table 4.5 Children activities of 7 years old

General Characteristic	Number (%) N = 39
Activity at home	
Housework	15 (38.5)
Play with friends	13 (33.3)
Cycling	5 (12.8)
Homework	4 (10.2)
Draw/Paint	2 (5.2)
Total	39 (100)
Watches television	
Do not watching television	1 (2.6)
Watching **television**	38 (97.4)
Total	39 (100)
- **Hour watching television**	
- 1 hour and lower per week	4 (10.5)
- 1-2 hour/week	24 (63.1)
- 2-3 hour/week	3 (7.9)
- 3-4 hour/week	2 (5.3)
- 4 hour and over per week	5 (13.2)
Total	38 (100)

Table 4.5 Children activities of 7 years old (cont.)

General Characteristic	Number (%) N = 39
Play computer game	
Do not playing computer game	11 (28.2)
Playing computer game	28 (71.8)
Total	39 (100)
- **Hour playing computer game**	
- 1 hour and lower per week	7 (25)
- 1-2 hour/week	17 (60.7)
- 2-3 hour/week	3 (10.7)
- 3-4 hour/week	1 (3.6)
Total	28 (100)

For school-aged school 8 to 9 years (N = 84) the results of activities showed that 19% did cycling activities, 17.9% of the sample did housework activities, 17.9% played with friends activities, and 13.1% did homework activities. For sample watching television and playing computer game, 98.8% of the sample watching television, and 75% playing computer game. 39.8% of the sample watches television 1-2 hours per week, 25% for 1 hours and lower per week, and 19.3% for 2-3 hours per week. 55.6% of the sample playing computer game for 1-2 hours per week, 27% for 1 hours and lower per week, and 11.1% for 2-3 hours per week.

Table 4.6 Children activities of 8 to 9 years old

General Characteristic	Number (%) N = 84
Activity at home	
Draw/Paint	10 (11.9)
Homework	11 (13.1)
Housework	15 (17.9)
Play with friends	15 (17.9)
Play music	1 (1.2)
Play sport	9 (10.7)
Play doll/robot	1 (1.2)
Cycling	16 (19.0)
Do it yourself	1 (1.2)
Etc.	5 (6.0)
Total	84 (100)
Watches television	
Do not watching television	1 (1.2)
Watching television	83 (98.8)
Total	84 (100)
- **Hour watching television**	
- 1 hour and lower per week	21 (25.0)
- 1-2 hour/week	33 (39.8)
- 2-3 hour/week	16 (19.3)
- 3-4 hour/week	6 (7.2)
- 4 hour and over per week	7 (8.4)
Total	83 (100)

Table 4.6 Children activities (cont.)

General Characteristic	Number (%) N = 84
Play computer game	
Do not playing computer game	21 (25.0)
Playing computer game	63 (75.0)
Total	84 (100)
- **Hour playing computer game**	
- 1 hour and lower per week	17 (27.0)
- 1-2 hour/week	35 (55.6)
- 2-3 hour/week	7 (11.1)
- 3-4 hour/week	2 (11.1)
- 4 hour and over per week	2 (3.2)
Total	63 (100)

4.2 Section II: The significant correlations between the Visual-Motor Integration (VMI) and the Task of Executive Control (TEC)

For research question: Were there any statistically significant correlations between each subscale of Visual-Motor Integration, as measured by the Visual-Motor Integration (VMI) and each subscale of Executive Control, as measured by the Task of Executive Control (TEC) in school age children?

This section showed the results of the correlation between each subscale of Visual-Motor Integration (VMI) (i.e., Visual-Motor Integration, Visual perception, and Motor Coordination) and each subscale of Task of Executive Control (TEC) (i.e., Accuracy, Attention, and Speed). Base on empirical evidence of age development, explain that school-aged children 7 year are final age in early childhood and school-aged children 8-9 year are start age in school-aged children, which is divided into 2 sections as follows.

4.2.1 Section I: The correlation between each subscale of Visual-Motor Integration (VMI) and each subscale of Task of Executive Control (TEC) in children 7 year.

4.2.1.1 The correlation between Visual-Motor Integration and each subscales of Task of Executive Control (TEC) in children 7 year.

Table 4.7 The correlation between Visual-Motor Integration and Accuracy

	Visual-Motor Integration	Accuracy
Visual-Motor Integration	1	
Accuracy	.351*	1

*Note: * Correlation is significant as the 0.05 level (2-tailed).*

The table 4.7 showed that the Visual-Motor Integration of children was significantly positive correlated to Accuracy ($r= 0.35$, $p < 0.05$). It was indicated that children with higher mean scores on Visual-Motor Integration tended to have higher mean scores on Accuracy.

Table 4.8 The correlation between Visual-Motor Integration and Attention

	Visual-Motor Integration	Attention
Visual-Motor Integration	1	
Attention	.378*	1

*Note: * Correlation is significant as the 0.05 level (2-tailed).*

The table 4.8 showed that the Visual-Motor Integration of children was significantly positive correlated to Attention ($r= 0.38$, $p < 0.05$). It was indicated that children with higher mean scores on Visual-Motor Integration tended to have higher mean scores on Attention.

Table 4.9 The correlation between Visual-Motor Integration and Speed

	Visual-Motor Integration	Speed
Visual-Motor Integration	1	
Speed	.254*	1

*Note: * Correlation is significant as the 0.05 level (2-tailed).*

The table 4.9 showed that the Visual-Motor Integration of children was significantly positive correlated to Speed ($r = 0.25$, $p < 0.05$). It was indicated that children with higher mean scores on Visual-Motor Integration tended to have higher mean scores on Speed.

4.2.1.2 The correlation between Visual Perception and each subscales of Task of Executive Control (TEC) in children 7 year.

Table 4.10 The correlation between Visual Perception and Accuracy

	Visual Perception	Accuracy
Visual Perception	1	
Accuracy	.482**	1

*Note: ** Correlation is significant as the 0.01 level (2-tailed).*

The table 4.10 showed that the Visual Perception of children was significantly positive correlated to Accuracy ($r = 0.48$, $p < 0.01$). It was indicated that children with higher mean scores on Visual Perception tended to have higher mean scores on Accuracy.

Table 4.11 The correlation between Visual Perception and Attention

	Visual Perception	**Attention**
Visual Perception	1	
Attention	.804**	1

*Note: ** Correlation is significant as the 0.01 level (2-tailed).*

The table 4.11 showed that the Visual Perception of children was significantly positive correlated to Attention (r= 0.80, $p < 0.01$). It was indicated that children with higher mean scores on Visual Perception tended to have higher mean scores on Attention.

Table 4.12 The correlation between Visual Perception and Speed

	Visual Perception	**Speed**
Visual Perception	1	
Speed	.203*	1

*Note: * Correlation is significant as the 0.05 level (2-tailed).*

The table 4.12 showed that the Visual Perception of children was significantly positive correlated to Speed (r= 0.20, $p < 0.05$). It was indicated that children with higher mean scores on Visual Perception tended to have higher mean scores on Speed.

4.2.1.3 The correlation between Motor Coordination and each subscales of Task of Executive Control (TEC) in children 7 year.

Table 4.13 The correlation between Motor Coordination and Accuracy

	Motor Coordination	**Accuracy**
Motor Coordination	1	
Accuracy	.252	1

The table 4.13 showed that the Motor Coordination of children was not significantly correlated to Accuracy (r= 0.25, $p > 0.05$). It was indicated that children with scores on Motor Coordination was not correlated to scores on Accuracy.

Table 4.14 The correlation between Motor Coordination and Attention

	Motor Coordination	**Attention**
Motor Coordination	1	
Attention	.695**	1

*Note: ** Correlation is significant as the 0.01 level (2-tailed).*

The table 4.14 showed that the Motor Coordination of children was significantly positive correlated to Attention (r= 0.70, $p < 0.01$). It was indicated that children with higher mean scores on Motor Coordination tended to have higher mean scores on Attention.

Table 4.15 The correlation between Motor Coordination and Speed

	Motor Coordination	Speed
Motor Coordination	1	
Speed	.397*	1

*Note: * Correlation is significant as the 0.05 level (2-tailed).*

The table 4.15 showed that the Motor Coordination of children was significantly positive correlated to Speed (r= 0.40, $p < 0.05$). It was indicated that children with higher mean scores on Motor Coordination tended to have higher mean scores on Speed.

Table 4.16 The summary of the significantly correlation between the Visual-Motor Integration (VMI) the Task of Executive Control (TEC) in children 7 year.

Visual-Motor Integration (VMI)	Task of Executive Control (TEC)		
	Accuracy	Attention	Speed
Visual-Motor Integration	.351*	.378*	.254*
Visual Perception	.482**	.804**	.203*
Motor Coordination	.252	.695**	.397*

*Note: ** Correlation is significant as the 0.01 level (2-tailed).*

** Correlation is significant as the 0.05 level (2-tailed).*

4.2.2 Section II: The correlation between each subscale of Visual-Motor Integration (VMI) and each subscale of Task of Executive Control (TEC) in children 8-9 years.

4.2.2.1 The correlation between Visual-Motor Integration and each subscales of Task of Executive Control (TEC) in children 8-9 years.

Table 4.17 The correlation between Visual-Motor Integration and Accuracy

	Visual-Motor Integration	**Accuracy**
Visual-Motor Integration	1	
Accuracy	.388**	1

*Note: ** Correlation is significant as the 0.01 level (2-tailed).*

The table 4.17 showed that the Visual-Motor Integration of children was significantly positive correlated to Accuracy ($r= 0.39$, $p < 0.01$). It was indicated that children with higher mean scores on Visual-Motor Integration tended to have higher mean scores on Accuracy.

Table 4.18 The correlation between Visual-Motor Integration and Attention

	Visual-Motor Integration	**Attention**
Visual-Motor Integration	1	
Attention	.248**	1

*Note: ** Correlation is significant as the 0.01 level (2-tailed).*

The table 4.18 showed that the Visual-Motor Integration of children was significantly positive correlated to Attention ($r= 0.25$, $p < 0.01$). It was indicated that children with higher mean scores on Visual-Motor Integration tended to have higher mean scores on Attention.

Table 4.19 The correlation between Visual-Motor Integration and Speed

	Visual-Motor Integration	**Speed**
Visual-Motor Integration	1	
Speed	.204*	1

*Note: * Correlation is significant as the 0.05 level (2-tailed).*

The table 4.19 showed that the Visual-Motor Integration of children was significantly positive correlated to Speed (r= 0.20, p < 0.05). It was indicated that children with higher mean scores on Visual-Motor Integration tended to have higher mean scores on Speed.

4.2.2.2 The correlation between Visual Perception and each subscales of Task of Executive Control (TEC) children 8-9 years.

Table 4.20 The correlation between Visual Perception and Accuracy

	Visual Perception	**Accuracy**
Visual Perception	1	
Accuracy	.260**	1

*Note: ** Correlation is significant as the 0.01 level (2-tailed).*

The table 4.20 showed that the Visual Perception of children was significantly positive correlated to Accuracy (r= 0.26, p < 0.01). It was indicated that children with higher mean scores on Visual Perception tended to have higher mean scores on Accuracy.

Table 4.21 The correlation between Visual Perception and Attention

	Visual Perception	Attention
Visual Perception	1	
Attention	.521**	1

*Note: ** Correlation is significant as the 0.01 level (2-tailed).*

The table 4.21 showed that the Visual Perception of children was significantly positive correlated to Attention ($r = 0.52$, $p < 0.01$). It was indicated that children with higher mean scores on Visual Perception tended to have higher mean scores on Attention.

Table 4.22 The correlation between Visual Perception and Speed

	Visual Perception	Speed
Visual Perception	1	
Speed	.418**	1

*Note: ** Correlation is significant as the 0.01 level (2-tailed).*

The table 4.22 showed that the Visual Perception of children was significantly positive correlated to Speed ($r = 0.42$, $p < 0.01$). It was indicated that children with higher mean scores on Visual Perception tended to have higher mean scores on Speed.

4.2.2.3 The correlation between Motor Coordination and each subscales of Task of Executive Control (TEC) children 8-9 years.

Table 4.23 The correlation between Motor Coordination and Accuracy

	Motor Coordination	**Accuracy**
Motor Coordination	1	
Accuracy	.503**	1

*Note: ** Correlation is significant as the 0.01 level (2-tailed).*

The table 4.23 showed that the Motor Coordination of children was significantly positive correlated to Accuracy ($r = 0.50$, $p < 0.01$). It was indicated that children with higher mean scores on Motor Coordination tended to have higher mean scores on Accuracy.

Table 4.24 The correlation between Motor Coordination and Attention

	Motor Coordination	**Attention**
Motor Coordination	1	
Attention	.553**	1

*Note: ** Correlation is significant as the 0.01 level (2-tailed).*

The table 4.24 showed that the Motor Coordination of children was significantly positive correlated to Attention ($r = 0.55$, $p < 0.01$). It was indicated that children with higher mean scores on Motor Coordination tended to have higher mean scores on Attention.

Table 4.25 The correlation between Motor Coordination and Speed

	Motor Coordination	Speed
Motor Coordination	1	
Speed	.285**	1

*Note: ** Correlation is significant as the 0.01 level (2-tailed).*

The table 4.25 showed that the Motor Coordination of children was significantly positive correlated to Speed ($r = 0.29$, $p < 0.01$). It was indicated that children with higher mean scores on Motor Coordination tended to have higher mean scores on Speed.

Table 4.26 The summary of the significantly correlation between the Visual-Motor Integration (VMI) the Task of Executive Control (TEC) in children 8-9 years.

Visual-Motor Integration (VMI)	Task of Executive Control (TEC)		
	Accuracy	Attention	Speed
Visual-Motor Integration	.388**	.248**	.204*
Visual Perception	.260**	.521**	.418**
Motor Coordination	.503**	.553**	.285**

*Note: ** Correlation is significant as the 0.01 level (2-tailed).*

** Correlation is significant as the 0.05 level (2-tailed).*

In summary, this chapter reported the results from data analyses using bivariate correlation statistic to investigate the significant correlations between the VMI and the TEC. The results showed the significantly positive correlations among the VMI subscales of the TEC subscales. In next chapter, a summary of certain findings and discussions for specific findings are provided.

CHAPTER V
DISCUSSION

This chapter is discussion in debt of result finding compare with several previously research and further to provide gap, limitation, impact and advantage of this finding study and last but far more least is suggestion for further study. This study aimed to investigate the significant correlations between Visual-Motor Integration (VMI) and Task of Executive Control (TEC) in school-aged children. The sample of this study was selected by the multistage random sampling represented the population in Prathai District, Nakornratchasima. The total sample included 123 school-aged children from Bantaoykraton School in Prathai District, Nakornratchasima. A bi-variate correlation was utilized to examine the significant correlations between VMI (i.e., Visual-Motor Integration, Visual Perception, and Motor Coordination) as measured by VMI and Executive Control (i.e., Accuracy, attention, and Speed) as measured by the TEC. The findings showed the significant correlations among the VMI subscales and the TEC subscales. The results showed that all VMI subscales (i.e., Visual-Motor Integration, Visual Perception, and Motor Coordination) were positively correlated with 3 subscales of the TEC; including accuracy, attention, and speed. The findings showed that the higher scores of Visual-Motor Integration skills, the higher scores of working memory and Inhibitory control skills as measured by attention, speed, and accuracy of TEC.

This chapter provides summaries and discussions of certain findings. It contains 3 sections. The first section provides rich discussions of the critical role of visual-motor integration, working memory, and inhibitory control. The second section provides rich discussions of the findings in research question regarding the significant correlations between VMI and TEC in school-aged children between 7 to 9 years old. The implications and pertinent research-based evidence for this study in which the findings can be applied are presented. Finally, the third section was a discussion on limitations and suggestions for further research.

5.1 The critical role of visual-motor integration, working memory, and inhibitory control

The findings of the research suggested that VMI contained visual perception and motor coordination. The results showed that VMI scores increased by ages. VMI scores were acquired by subscale scores of visual perception and motor coordination. VMI scores in 8-year-old children were better than those of 7-year-old children and VMI scores of 9-year old children were better than children at 7-8 years old. The findings of this research were consistent with the previous research regarding the brain development of VMI. Teresa Farroni and Enrica Menon, (2008) found that the children aged 5 to7 years old had completed their development of basic functions at primary sensory areas of the cortex, and the functional development of brain in school-aged children aged between 8-9 years can be recognized for their complex sense of visual and motor integration. Children acquired subscales, visual perception and motor coordination for functioning of fingers coordination (24, 25). The findings suggested that older children had more efficiency of brain for controlling their visual perception, motor coordination, and VMI than younger children. The performance of complex brain helped children control behaviors of visual perception and integrated perceived vision for actions to motor coordination as well. In other research studies, children used the visual-motor integration in their daily activities. The research conducted by Graham S. (1998) found that handwriting was a skill that children acquired to meet the common demands of classroom work that involved the combined visual perception, motor coordination, and VMI. This finding may concluded that older children could control handwriting based on the manipulate vision through the visual perception and control hand writing through the motor coordination, which is a function of the visual-motor integration than younger children (4).

For the working memory and inhibitory control, the findings of this research also suggested that the ability of working memory and inhibitory control was based on the child's development in 3 subscales including attention, speed, and accuracy. Children acquired attention for managing information and memory to learn and control speed and accuracy for controlling their impulses and thinking before acting. These would be more complicated by ages (27). The results showed that children at 9 years old had better scores on attention, speed, and accuracy than those aged between 7-8 years old. The findings of this research were consistent with the previous research in the development of working memory and inhibitory control (12). Hitch, G, J. (1990) found that the trend of children's working memory and inhibitory control had significantly increased by ages. Therefore older children are usually paid more attention to details, inhibited speed time, and controlled accuracy to learning in classroom than younger children (27).

In summary, the findings in this current research indicated that scores of VMI were evaluated by visual perception, motor coordination, and VMI. Working memory and Inhibitory control were evaluated by attention, speed, and accuracy in children aged 7-9 years, which would be developed by age. Children required these skills in classroom. The previous research gave some supportive findings as described in the literature review.

5.2 The significant correlations between Visual Motor Integration Skills and Working Memory and Inhibitory Control

The analysis results that 3 subscales of VMI, including VMI, Visual Perception, and Motor Coordination were significantly and positively correlated with Executive Control, working memory and inhibitory control, including Accuracy, Attention, and Speed. The finding confirmed the hypothesis of the study that there were some statistically significant correlations among VMI subscales and TEC subscales. The findings were consistent with the previous research in children's visual-motor integration development and children's executive control development.

For children at 7 years old, the results of this research also showed that VMI subscales, including VMI, Visual Perception, and Motor Coordination were significantly and positively correlated with TEC subscales, including Accuracy, Attention, and Speed. The finding confirmed the hypothesis of the study that there were some statistically significant correlations among VMI subscales and TEC subscales. These findings were consistent with the impact of visual-motor integration on children's working memory, which focused on visual-motor integration and attention, and speed. The finding of this study was consistent with a previous research conducted by Taylor Kulp M. in 1999 with 191 children, 5 to 6 years and 7 to 9 years to examine the correlations among visual-motor integration (using the Beery VMI test) and academic achievements. The results showed that the visual-motor integration was significantly correlated with only reading achievement rating in 7-year old children. The visual-motor integration was significantly correlated with reading, writing, spelling, and math achievement rating in children aged 8 to 9 years old, but not in the children aged 5 to 6 years old. The results suggested that children at 5 years old would acquire half of Visual-Motor Integration, which would be greatly developed when they were at 7 years old. It would become automatic and organized. VMI would be further developed when the children studied at Grade 3 (aged between 8 to 9 years) (53). The finding was consistent with a previous research conducted by Graham S, Berninger V, Weintraub N & Schafer W., 1998, who found that the handwriting when children studying at Grade 1 to 9 were correlated with speed of handwriting (4). The researchers suggested that the children's control of handwriting was correlated with a control speed of writing (49).

The results (children at 7 years old) showed that the motor coordination was not correlated with accuracy. For the motor coordination, the result was consistent with the results of the past research on childhood as conducted by Eva Michel, 2012, who found that the motor coordination performance predicted the executive functioning, which included attention, speed, and accuracy. It was also expected that the Executive Function could predict the motor performance because it has been known that the Executive Functions were done by cognitive processes responsible for cognitive and motor coordination (54). In addition, there were other factors relating to incorrect handwriting such as size and height of letters, variable slant and poor alignment, irregular spacing between words and letters, and poor coordination of the fine motor. The research suggested that children who could control motor coordination might play an important role in children's development of writing accuracy (2). The result of this study was contrary to the previous research that may be explained by the small sample group of this research.

For children at 8 to 9 years old, the results of this research also showed that VMI subscales, including VMI, Visual Perception, and Motor Coordination were significantly and positively correlated with TEC subscales, including Accuracy, Attention, and Speed. This finding confirmed the hypothesis of the study that there were some statistically significant correlations among VMI subscales and TEC subscales. The findings were consistent with the impact of visual-motor integration on children's working memory, which focused on visual-motor integration and attention, speed, and accuracy. The finding of this study was consistent with a previous research conducted by Graham S. (1998) with 900 children in Grade 1 to 9 to examine the relationships among visual-motor integration and handwriting skills. The results showed that the children who could control visual perception, motor coordination, and visual-motor integration showed significant contributions to the children's speed and accuracy. Children with high visual-motor integration were more likely to faster and more precise writing when they become adults. The researchers suggested that the handwriting was smooth when children could control their visual perception and motor coordination as well (4). Likewise, the children with attention efficiency were more likely to visual-motor integration for selecting and visual information over space and over time on handwriting (49). In this research, the children who had low visual perception and low motor coordination tended to have lower speed, accuracy, and attention skills when compared with the children who had more visual perception and motor coordination. It could be explained that the children with low visual-motor integration could not organize and remember the information in working memory for writing. They generally had a problem of manipulating information for action motor (9, 36).

In addition, visual perception, motor coordination, and visual-motor integration supported children's learning because visual memory is essential task for all classroom learning (20, 37). As a result, it could be possible to explain that the visual-motor integration subscales were significantly correlated with working memory because children learnt how to monitor and code the incoming information to manipulate the motor action. Therefore the strong visual-motor integration task a tended to correlated with higher working memory skills.

Regarding the children's VMI and working memory scores, the children who had lower VMI scores, but have been encouraged for the visual-motor integration, their visual-motor integration abilities would be built effectively and their working memory abilities would be increasing. This was consistent with the research conducted by Hitch, G, J. (1990) who found that children with high visual-motor integration scores would make great recognition scores (27). It could be possibly explained that when the children's visual-motor integration was supported, they would have the strong working memory.

Moreover, the results of this research also showed that the visual-motor integration was significantly correlated with the inhibitory control. The findings were also consistent with the previous research regarding influences of motor coordination on school-aged children's inhibitory control. The previous research suggested that motor coordination was one of the strongest influences on children's inhibit (34).

Regarding the quality of motor coordination and inhibitory control, the finding of this research was consistent with the previous research on the impact of motor coordination and children's inhibitory control in 238 school-aged children. The results showed that the composite scores of motor coordination were related to children's performance on inhibitory control tasks (11). Since the motor coordination was the children' perception to control their body function that they have sufficiently inhibit emotional and motor action. It could be possibly explained that when the children had enough motor coordination, they were more likely to have better emotional and practical action.

In addition, the finding from this study also showed the correlation between the visual-motor integration and the executive function including working memory and inhibitory control. The results of this study was consistent with a previous research conducted by Böhm et al. (2010) to examine longitudinal relationships among the visual-motor and executive function in 175 preterm children and 125 full-term children in Stockholm Neonatal Project to. The results showed that children's visual-motor skill made significant contributions to the cognitive levels. Multiple Regression Analysis showed that hyperactive behavior, inattention, lower of speed movement and inaccuracy of movement increased the risk for visual-motor deficits were found in preterm children whereas there was no additional risk among hyperactive term children (7). The researchers suggested that low attention, speed, and accuracy of executive function were correlated with low visual-motor deficits in preterm children because they were unable to control the integration of visual perception and motor coordination. These children tended to have low executive function skills if compared with full-term children.

There was also evidence that visual-motor integration was another visual perception skill and motor coordination skills that children need to acquire to meet the common demands of executive function performance (3, 33). As a result, it could be possible to explain that the VMI subscales were significantly correlated with Executive Control. Since the children have never learned to control their own visual perception, motor coordination, and visual-motor integration, they tended to have more inattention and lack of inhibitory control that related to low Executive Control skills.

In summary, the results of this research showed that VMI subscales, including Visual-Motor Integration, Visual Perception, and Motor Coordination were significantly and positively correlated with the Executive Control, especially working memory and inhibitory control. The finding confirmed the hypothesis of the study that there were some statistically significant correlations among VMI subscales and TEC subscales. It could be possible to explain that the children with high visual-motor integration would have strong working memory and maintain their inhibitory control.

5.3 Limitations and Suggestions for Further Research

In this study, there were several limitations that affected the findings. There were some threats regarding the external and internal validity. For the threats to external validity, the sample size was relatively small if compared with general population in the central region of Thailand. Thus, it might not represent all children's visual-motor integration and children's executive control in Bantoeykraton School, Nakornratcharima. Therefore, further research should involve larger sample size in schools from different districts and provinces to reduce the threat to external validity.

For the threat to internal validity, the instruments were the limitation of this study. Due to the long processes of the instruments, including 3 levels of TEC, 6 game tasks, and using 10 minutes for each game, the children difficultly paid attention and maintained concentration to finish the tasks. Therefore, for the future research, a short version of TEC for children should be developed.

For the suggestion, the results of this study indicated the need to further investigate how all subscales of visual-motor integration are correlated with all subscales of executive function. However, anyone who would like to develop some task programs for testing visual-motor integration, the focus should be on the correlation of subscales of executive function such as shifting, planning and organization, and emotional control between visual-motor integration and executive function.

CHAPTER VI
CONCLUSION

According to the findings from the data analyses, using a bi-variant correlation to investigate the significant correlations between the VMI and the TEC, the results of the current research provided the evidence that supported the hypothesis of the research study that there were some any statistically significant correlations between the subscales of visual-motor integration and the subscales of executive control.The results showed that there were significantly positive correlations among the two sets of subscale data. The results indicated that children's with high level of the visual-motor integration skills had significantly positive correlations with the children's with high level of the working memory and inhibitory control skills. These findings can explained that the children's with high level of the visual-motor integration skills correlation with the children's with high level of the attention, speed, and accuracy.

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APPENDICES

APPENDIX A
CERTIFICATE OF APPROVAL

COA. No. 2013/112.0411

Certificate of Approval
Mahidol University Institutional Review Board (MU-IRB)

Protocol No.: MU-IRB 2013/118.2309

Title of Project: Correlation Between the Visual-Motor Integration (vmi) and the Task of Executive Control (TEC) in School Age Children Between 7 to 9 Years (Thesis for Master Degree)

Principal Investigator: Ms. Krittiyanee Thammasarn

Affiliation: National Institute for Child and Family Development

Approval includes: 1) MU-IRB Submission form version date 1 November 2013
2) Assent form version date 1 November 2013
3) Participant Information sheet for Parent version date 1 November 2013
4) Informed Consent form for Parent version date 1 November 2013
5) Questionnaire version date 1 November 2013

Mahidol University Institutional Review Board is in full compliance with International Guidelines for Human Research Protection such as Declaration of Helsinki, The Belmont Report, CIOMS Guidelines and the International Conference on Harmonization in Good Clinical Practice (ICH-GCP)

Date of Approval: 4 November 2013

Date of Expiration: 3 November 2013

Signature of MU-IRB Chair: .... 4 November 2013
(Professor Shusee Visalyaputra) version date

Signature of Institute Representative: .... 4 November 2013
(Professor Prasit Palittapongarnpim) version date
Vice President for Research

Office of the President, Mahidol University, 999 Phuttamonthon 4 Rd., Salaya, Phuttamonthon District,
Nakhon Pathom 73170. Tel. (662) 8496223-5 Fax. (662) 8496223

APPENDIX B
INFORM CONSENT FOR PARENT

หนังสือแสดงเจตนายินยอมเข้าร่วมการวิจัยโดยได้รับการบอกกล่าวและเต็มใจ

วันที่................ เดือน.................... พ.ศ. ....

ข้าพเจ้า.. อายุ............ปี อาศัยอยู่บ้านเลขที่....................

ถนน..ตำบล..อำเภอ..

จังหวัด..รหัสไปรษณีย์..............................โทรศัพท์ ....

ผู้แทนโดยชอบธรรมของ ด.ญ./ด.ช. ....

โดยเกี่ยวข้องเป็น ☐ บิดา มารดา ☐ปู่ ย่า ตา ยาย ☐ ลุง ป้า น้า อา ☐ อื่นๆ ระบุ.................

ขอแสดงเจตนายินยอมให้เด็กในปกครองของข้าพเจ้าเข้าร่วมโครงการวิจัยเรื่อง**การศึกษาความสัมพันธ์ระหว่างการประสานสัมพันธ์สายตา-กล้ามเนื้อสั่งการและกระบวนการคิดขั้นสูงในเด็กวัยเรียนอายุ 7 ถึง 9 ปี**

โดยข้าพเจ้าได้รับทราบรายละเอียดเกี่ยวกับที่มาและจุดมุ่งหมายในการทำวิจัยรายละเอียดขั้นตอนต่างๆ ที่จะต้องปฏิบัติหรือได้รับการปฏิบัติ ประโยชน์ที่คาดว่าจะได้รับของการวิจัย และความเสี่ยงที่อาจจะเกิดขึ้นจากการเข้าร่วมการวิจัย รวมทั้งแนวทางป้องกันและแก้ไขหากเกิดอันตราย โดยได้อ่านข้อความที่มีรายละเอียดอยู่ในเอกสารชี้แจงผู้เข้าร่วมการวิจัยโดยตลอด อีกทั้งยังได้รับคำอธิบายและตอบข้อสงสัยจากหัวหน้าโครงการวิจัยเป็นที่เรียบร้อยแล้ว โดยไม่มีสิ่งใดปิดบังซ่อนเร้น

ข้าพเจ้าจึงสมัครใจให้เด็กในปกครองของข้าพเจ้าเข้าร่วมในโครงการวิจัยนี้ :

ข้าพเจ้าได้รับทราบถึงสิทธิ์ที่ข้าพเจ้าจะได้รับข้อมูลเพิ่มเติมทั้งทางด้านประโยชน์และโทษจากการเข้าร่วมการวิจัย และสามารถถอนตัวหรืองดเข้าร่วมการวิจัยได้ทุกเมื่อ โดยจะไม่มีผลกระทบต่อการที่ข้าพเจ้าจะได้รับต่อไปในอนาคต และยินยอมให้ผู้วิจัยใช้ข้อมูลส่วนตัวของข้าพเจ้าที่ได้รับจากการวิจัย แต่จะไม่เผยแพร่ต่อสาธารณะเป็นรายบุคคล โดยจะนำเสนอเป็นข้อมูลโดยรวมจากการวิจัยเท่านั้น

หากมีอาการผิดปกติ รู้สึกไม่สบายกาย หรือมีผลกระทบต่อจิตใจของเด็กในปกครองของข้าพเจ้าเกิดขึ้นระหว่างการวิจัย ข้าพเจ้าจะแจ้งผู้วิจัยโดยเร็วที่สุด หากข้าพเจ้ามีข้อข้องใจเกี่ยวกับขั้นตอนของการวิจัย หรือหากเกิดผลข้างเคียงที่ไม่พึงประสงค์จากการวิจัยขึ้นกับเด็กในปกครองของข้าพเจ้า ข้าพเจ้าจะสามารถติดต่อกับ นางสาวกฤติยาณี ธรรมสาร โทร 083-5456546

หากเด็กในปกครองของข้าพเจ้าได้รับการปฏิบัติไม่ตรงตามที่ได้ระบุไว้ในเอกสารชี้แจงผู้เข้าร่วมการวิจัย ข้าพเจ้าจะสามารถติดต่อกับประธานคณะกรรมการจริยธรรมการวิจัยในคนหรือผู้แทน ได้ที่สำนักงานคณะกรรมการจริยธรรมการวิจัยในคน สำนักงานอธิการบดีมหาวิทยาลัยมหิดล โทร. 02-849-6223-5 โทรสาร 02-849-6223

ข้าพเจ้าเข้าใจข้อความในเอกสารชี้แจงผู้เข้าร่วมการวิจัย และหนังสือแสดงเจตนายินยอมนี้โดยตลอดแล้ว จึงลงลายมือชื่อไว้

ลงชื่อ...ผู้ปกครอง

(...) วันที่..........................

ลงชื่อ..ผู้ให้ข้อมูลและขอความยินยอม/หัวหน้าโครงการวิจัย

(..) วันที่............................

รับรองโดยคณะกรรมการจริยธรรมการวิจัยในคน
มหาวิทยาลัยมหิดล
รหัสโครงการ MU-IRB 2013/114.2309
วันที่ 4 พฤศจิกายน 2556

Informed Consent form for Parent version 1 November 2013

APPENDIX C
INFORM CONSENT FOR CHILDREN 7 TO 9 YEARS

คำอธิบายโครงการวิจัยและการขอความยินยอมสำหรับเด็กอายุ 7-9 ปี

โครงการวิจัยนี้ทำขึ้นเพื่อ ศึกษาว่าเด็กน้องๆชั้นประถมศึกษาปีที่ 1-3 ในโรงเรียนบ้านหันเตยมีการทำงานระหว่างการประสานสัมพันธ์สายตา-กล้ามเนื้อสั่งการ และกระบวนการคิดขั้นสูงมีความสัมพันธ์กันหรือไม่

พี่อยากจะศึกษาว่าน้องๆมีการทำงานระหว่างการประสานสัมพันธ์สายตา-กล้ามเนื้อสั่งการ และกระบวนการคิดขั้นสูงมีความสัมพันธ์กันหรือไม่

พี่ชวนน้องเข้าร่วมโครงการนี้เพราะว่าน้องเป็นเด็กนักเรียนชั้นประถมศึกษาปีที่ 1-3 ในโรงเรียนบ้านหันเตย ที่มีสุขภาพแข็งแรง และไม่มีปัญหาทางด้านการเรียนรู้

ถ้าน้องยินดีร่วมโครงการนี้ น้องจะได้รับการปฏิบัติดังนี้

1. พี่จะขอให้น้องวัดการประสานสัมพันธ์สายตาและกล้ามเนื้อสั่งการ โดยจะให้น้องเขียนและการวาดภาพ น้องจะได้ทำกับเพื่อนเป็นกลุ่มๆ กลุ่มละ 3-4 คน **ใช้เวลา 30 นาที**
2. น้องจะได้วัดกระบวนการคิดขั้นสูงด้วยโปรแกรมเกมส์จากคอมพิวเตอร์ โดยเกมส์จะให้น้องจำภาพต่างๆ **ใช้เวลา 15-20 นาทีต่อคน**

รวมระยะเวลาที่น้องทำแบบวัดประมาณ 1 ชั่วโมง โดยน้องจะได้ทำแบบวัดในช่วงก่อนเข้าแถวเคารพธงชาติ, หรือช่วงพักกลางวัน หรือช่วงหลังเลิกเรียนค่ะ

งานวิจัยนี้มีความเสี่ยงน้อย พี่จะคอยดูแลน้องอย่างดี ไม่ให้น้องเหนื่อยเกินไป แต่ถ้าน้องรู้สึกไม่สบายใจ อึดอัด ไม่อยากเข้าร่วมในการวิจัยนี้ น้องสามารถบอกพี่ได้ตลอดเวลา และถ้าน้องหรือผู้ปกครองมีเรื่องสงสัยประการใด สามารถถามได้ **พี่ชื่อ พี่ดิว (นางสาวกฤติยาณี ธรรมสาร) หมายเลขโทรศัพท์ 083-5456546** ได้ตลอดเวลา

พี่จะเก็บเรื่องส่วนตัวน้องเป็นความลับ ไม่เปิดเผยให้ใครทราบ

น้องอ่านรายละเอียดแล้วเข้าใจหรือไม่

☐ เข้าใจ ☐ ไม่เข้าใจ

น้องมีข้อสงสัยต้องการซักถามพี่หรือไม่

☐ ต้องการถาม ☐ ไม่ต้องการถาม

น้องได้อ่านและเข้าใจรายละเอียดของโครงการแล้ว

☺ ถ้าน้องเต็มใจ เข้าร่วมในโครงการนี้ ลงชื่อ..

☹ ถ้าน้องไม่เต็มใจเข้าร่วมโครงการนี้ ลงชื่อ..

Assent form version 1 November 2013

รับรองโดยคณะกรรมการจริยธรรมการวิจัยในคน
มหาวิทยาลัยมหิดล
รหัสโครงการ MU-IRB 2013/118.2309
วันที่ 4 พฤศจิกายน 2556

APPENDIX D
PARTICIPANT INFORMATION SHEET FOR PARENT

เอกสารชี้แจงผู้เข้าร่วมการวิจัยสำหรับผู้ปกครอง

(Participant Information Sheet)

ในเอกสารนี้อาจมีข้อความที่ท่านอ่านแล้วยังไม่เข้าใจ โปรดสอบถามหัวหน้าโครงการวิจัย หรือผู้แทนให้ช่วยอธิบายจนกว่าจะเข้าใจดี ท่านานจะได้รับเอกสารนี้ 1 ฉบับ นำกลับไปอ่านที่บ้านเพื่อปรึกษาหารือกับญาติพี่น้อง เพื่อน หรือผู้อื่นที่ท่านต้องการปรึกษา เพื่อช่วยในการตัดสินใจเข้าร่วมการวิจัย

ชื่อโครงการ การศึกษาความสัมพันธ์ระหว่างการประสานสัมพันธ์สายตา-กล้ามเนื้อสั่งการและกระบวนการคิดขั้นสูงในเด็กวัยเรียนอายุ 7 ถึง 9 ปี

ชื่อผู้วิจัย นางสาวกฤติยาณี ธรรมสาร

สถานที่ติดต่อ สถาบันแห่งชาติเพื่อการพัฒนาเด็กและครอบครัว มหาวิทยาลัยมหิดล ศาลายา หมายเลขโทรศัพท์ 083-545-6546

โครงการวิจัยนี้ทำขึ้นเพื่อ ศึกษาความสัมพันธ์ระหว่างการประสานสัมพันธ์สายตา-กล้ามเนื้อสั่งการและกระบวนการคิดขั้นสูงในเด็กวัยเรียนอายุ 7 ถึง 9 ปี ซึ่งประโยชน์ที่คาดว่าจะได้รับคือ เด็กที่เข้าร่วมโครงการวิจัยจะได้รับการประเมินการประสานสัมพันธ์สายตาและกล้ามเนื้อสั่งการ และการประเมินกระบวนการคิดขั้นสูง ซึ่งจะมีประโยชน์ให้ผู้วิจัยได้ทราบค่าเฉลี่ยของการพัฒนาการประสานสัมพันธ์สายตาและกล้ามเนื้อสั่งการและกระบวนการคิดขั้นสูงในกลุ่มเด็กอายุ 7-9 ปี

เด็กในปกครองของท่านได้รับเชิญให้เข้าร่วมการวิจัยนี้เพราะ มีอายุระหว่าง 7-9 ปี และมีสุขภาพสมบูรณ์แข็งแรง และศึกษาอยู่ในโรงเรียนที่ได้รับการสุ่มให้เป็นกลุ่มตัวอย่างของการวิจัยนี้

จะมีผู้เข้าร่วมวิจัยนี้ทั้งสิ้นประมาณ 150 คน **เด็กแต่ละคนจะใช้เวลาในการเข้าร่วมการวิจัยคนละ 1 ชั่วโมง**

หากท่านตัดสินใจให้เด็กในความปกครองของท่านเข้าร่วมการวิจัยแล้ว จะมีขั้นตอนการวิจัยดังต่อไปนี้ คือ

1. **ผู้วิจัยจะขอให้ท่านตอบแบบสอบถาม** จำนวน 39 **ข้อ ใช้เวลาประมาณ 15 นาที** โดยเมื่อตอบเสร็จแล้วจะขอให้ท่านนำแบบสอบถามใส่ซอง และให้เด็กในปกครองของท่านถือกลับมาให้ครูประจำชั้น
2. ให้เด็กปกครองของท่านนำไปให้ท่าน และ
3. เด็กในปกครองของท่านจะได้รับการประเมินการประสานสัมพันธ์สายตาและกล้ามเนื้อสั่งการซึ่งการประเมินเป็นการใช้การเขียนและการวาดภาพ โดยดำเนินการเป็นกลุ่ม กลุ่มละ 3-4 คน **ใช้เวลาประมาณ 30 นาที**
4. เด็กในปกครองของท่านจะได้รับการประเมินกระบวนการคิดขั้นสูงซึ่งเป็นการประเมินโปรแกรมคอมพิวเตอร์จะมีลักษณะเป็นเกมส์จำภาพ ดำเนินการครั้งละ 1 คน **ใช้เวลาประมาณ 15-20 นาที**ต่อคน จำนวน 1 ครั้ง

เมื่อผู้วิจัยทราบผลการประเมินของเด็กในปกครองของท่าน ผู้วิจัยจะส่งจดหมายแจ้งผลประเมินให้ท่านและครูประจำชั้นทราบ

ความเสี่ยงที่อาจเกิดขึ้นระหว่างการเข้าร่วมการวิจัย คือ เด็กในปกครองของท่านอาจรู้สึกเหนื่อย หรือรู้สึกไม่สบายใจในการประเมินบางช่วง หรือรู้สึกอึดอัดไม่สบายใจบ้างกับบางคำถาม เด็กในปกครองของท่านมีสิทธิ์ที่จะไม่ตอบคำถามเหล่านั้นได้ ตลอดจนมีสิทธิ์ถอนตัวออกจากโครงการวิจัยเมื่อใดก็ได้ โดยไม่ต้องแจ้งให้ทราบล่วงหน้า และการไม่เข้าร่วมการวิจัยหรือถอนตัวออกจากโครงการวิจัยนี้ จะไม่มีผลกระทบใดๆต่อเด็กทั้งทางบ้านและผลการเรียน

รับรองโดยคณะกรรมการจริยธรรมการวิจัยในคน มหาวิทยาลัยมหิดล
รหัสโครงการ MU-IRB 2013/118.2309
วันที่ 4 พฤศจิกายน 2556

การเข้าร่วมการศึกษาในครั้งนี้ เด็กในปกครองของท่านจะไม่ได้รับผลกระทบและสิทธิประโยชน์ใดๆ และจะไม่มีค่าใช้จ่ายที่ท่านต้องรับผิดชอบ และเพื่อให้การเข้าร่วมการวิจัยในครั้งนี้ เป็นไปโดยสมัครใจ เด็กในปกครองของท่านสามารถปฏิเสธที่จะเข้าร่วมการวิจัยเมื่อใดก็ได้

หากท่านรู้สึกว่าเด็กในความปกครองของท่านอาจเกิดความเสี่ยงและความไม่สบายใจตลอดระยะเวลาในการวิจัย ท่านมีสิทธิถอนตัวเด็กในปกครองของท่านออกจากโครงการวิจัยเมื่อใดก็ได้และเด็กในปกครองของท่านจะไม่ได้รับผลกระทบต่อสิทธิประโยชน์ในด้านการเรียนและบริการใดๆที่พึงจะได้รับตามมาตรฐาน แต่หากเกิดความเสี่ยงและความไม่สบายใจแก่เด็กในปกครองของท่านผู้วิจัยและอาจารย์ที่ปรึกษาวิทยานิพนธ์หลักจะเป็นผู้รับผิดชอบในกรณีเหตุการณ์ไม่พึงประสงค์เหล่านั้น ผู้วิจัยจะเก็บข้อมูลของผู้เข้าร่วมวิจัยเป็นความลับ และจะเปิดเผยเฉพาะการสรุปผลการวิจัยในภาพรวมเท่านั้น

หากเด็กในปกครองของท่านรู้สึกไม่สบายใจระหว่างการวิจัย ท่านจะแจ้งผู้วิจัยโดยเร็วที่สุด หากท่านมีข้อสงสัยที่จะสอบถามเกี่ยวกับการวิจัย ท่านสามารถติดต่อ นางสาวกฤติยาณี ธรรมสาร นักศึกษา สถาบันแห่งชาติเพื่อการพัฒนาเด็กและครอบครัว มหาวิทยาลัยมหิดล หมายเลขโทรศัพท์ 083-5456546 หรือ ดร.วสุนันท์ ชุ่มเชื้อ (อาจารย์ที่ปรึกษา) หมายเลขโทรศัพท์ 081-9168983 ได้ตลอด 24 ชั่วโมง

โครงการวิจัยนี้ได้รับการพิจารณารับรองจากคณะกรรมการจริยธรรมการวิจัยในคน มหาวิทยาลัยมหิดล ซึ่งมีสำนักงานอยู่ที่ สำนักอธิการบดีมหาวิทยาลัยมหิดล ถนนพุทธมณฑลสาย 4 ตำบลศาลายา อำเภอพุทธมณฑล จังหวัดนครปฐม 73170 หมายเลขโทรศัพท์ 02-849-6223-5 โทรสาร 02-849-6223 หากเด็กในปกครองของท่านได้รับการปฏิบัติไม่ตรงตามที่ระบุไว้ ท่านสามารถติดต่อกับประธานคณะกรรมการฯหรือผู้แทน ได้ตามสถานที่และหมายเลขโทรศัพท์ข้างต้น ขอขอบพระคุณในความร่วมมือของท่านมา ณ ที่นี้

ข้าพเจ้าได้อ่านรายละเอียดในเอกสารนี้ครบถ้วนแล้ว

ลงชื่อ......................................

(..)

ผู้ปกครอง

วันที่...

ลงชื่อ......................................

(..)

ผู้แทนโดยชอบธรรม

วันที่...

รับรองโดยคณะกรรมการจริยธรรมการวิจัยในคน
มหาวิทยาลัยมหิดล
รหัสโครงการ MU-IRB 2013/118.2309
วันที่ 4 พฤศจิกายน 2556

APPENDIX E
PARENT AND CHILD'S INFORMATION QUESTION

แบบสอบถามสำหรับผู้ปกครอง

<u>คำชี้แจง</u> ขอให้ท่านโปรดอ่านข้อความต่อไปนี้แล้วกรุณาเติมข้อความลงในช่องว่าง และเขียน ✓ลง ใน ❒ หน้าข้อความที่ตรงกับความเป็นจริงมากที่สุด และกรุณาทำให้ครบทุกข้อ เพื่อความสมบูรณ์ของแบบสอบถาม

แบบสอบถามมีทั้งหมด 2 ส่วน รวมทั้งหมด 39 ข้อ

- ส่วนที่ 1 ข้อมูลเกี่ยวกับผู้ปกครอง มีทั้งหมด 10 ข้อ
- ส่วนที่ 2 ข้อมูลเกี่ยวกับเด็ก มีทั้งหมด 29 ข้อ

<u>ส่วนที่ 1</u> ข้อมูลเกี่ยวกับผู้ปกครอง

1. ผู้ตอบแบบสอบถามมีความเกี่ยวข้องกับเด็กเป็น
   - ❒ 1. บิดา ❒ 2. มารดา
   - ❒ 3. ปู่/ ย่า/ ตา/ ยาย ❒ 4. ลุง/ ป้า /น้า/ อา
   - ❒ 5. อื่นๆ (ระบุ)………………………………………
2. คนเลี้ยงดูหลักของเด็กคนนี้มากที่สุดคือใคร
   - ❒ 1. บิดาและมารดา ❒ 2. บิดา ❒ 3. มารดา
   - ❒ 4. พี่เลี้ยง ❒ 5. ปู่/ย่า ❒ 6. ตา/ยาย
   - ❒ 7. อื่นๆ (ระบุ)…………………..
3. สถานะภาพสมรสของบิดามารดา
   - ❒ 1. สมรสและอยู่ด้วยกัน ❒ 2. สมรสแต่แยกกันอยู่
   - ❒ 3. หย่าร้าง ❒ 4. ไม่ได้สมรสแต่อยู่ด้วยกัน
   - ❒ 5. หม้าย (คู่สมรสเสียชีวิต) ❒ 6. แยกกันอยู่ สาเหตุ

   เพราะ………………………..

ตัวเลือกระดับการศึกษา สำหรับข้อ 4-6

(1) ประถมศึกษา (2) มัธยมศึกษาตอนต้น (3) มัธยมศึกษาตอนปลาย

(4) ปริญญาตรี (5) ปริญญาโท (6) ปริญญาเอก

(7) ไม่ได้ศึกษา (8) อื่นๆ ระบุ…….…………….

กรุณาใส่หมายเลขหน้าข้อที่ตรงกับระดับการศึกษา

4. ระดับการศึกษาของ บิดา ……………………………….
5. ระดับการศึกษาของ มารดา…………………………...
6. ระดับการศึกษาของ ผู้เลี้ยงดูหลัก………………………

ตัวเลือกอาชีพ สำหรับ ข้อ 7-9

(1) รับราชการ (2) พนักงานรัฐวิสาหกิจ (3) พนักงานราชการ

(4) รับจ้างทั่วไป (5) ประกอบธุรกิจส่วนตัว/ค้าขาย (6) เกษตรกรรม

(7) ประมง (8) ลูกจ้างเอกชน (9) แม่บ้าน/พ่อบ้าน

(10) อื่นๆ ระบุ………………………….

กรุณาใส่หมายเลขหน้าข้อที่ตรงกับอาชีพ

7. อาชีพของ บิดา……………………………………………
8. อาชีพของ มารดา…………………………………………
9. อาชีพของ ผู้เลี้ยงดูหลัก ………………….………………
10. รายได้เฉลี่ยของครอบครัว (บาท/เดือน)

☐ ไม่มีรายได้ ☐ ต่ำกว่า 10,000 ☐ 10,001 – 20,000

☐ 20,001 – 30,000 ☐ 30,001 – 40,000 ☐ 40,001 – 50,000

☐ 50,001 ขึ้นไป ☐ อื่นๆ…………..

<u>ส่วนที่ 2</u> ข้อมูลเกี่ยวกับเด็ก

1. เด็กมีน้ำหนักแรกเกิด…………………………….กรัม
2. เด็กคลอดโดยวิธี ☐ คลอดปกติ ☐ ผ่าคลอด ☐ อื่นๆ ระบุ………………….
3. อายุครรภ์ที่คลอด………………………….เดือน
4. ปัจจุบัน เด็กมีน้ำหนัก…….………..…..กิโลกรัม ส่วนสูง……………….เซนติเมตร
5. เพศเด็ก ☐ 1.ชาย ☐ 2.หญิง
6. ปัจจุบันเด็กอายุ…………ปี……...เดือน (เกิดวันที่.....เดือน………..…..ปี………….)
7. กำลังศึกษาอยู่ระดับชั้น ☐ ป.1 ☐ ป.2 ☐ ป.3
8. เด็กเป็นลูกคนที่…………….. จากจำนวนพี่น้อง……………….คน
9. เด็กมีโรคประจำตัวหรือไม่
   ☐ 1.ไม่มี ☐ 2.ไม่ทราบ/ไม่เคยตรวจ
   ☐ 3.มี (ระบุ)……………………………………….
10. เด็กมีความพิการด้านร่างกายหรือไม่
   ☐ 1.ไม่มี ☐ 2.มี (ระบุ)……………….……….
11. เด็กเคยประสบอุบัติเหตุขั้นรุนแรง (เช่น ตกบ้าน , ตกน้ำ, ตกจากต้นไม้สูง, อุบัติเหตุทางจราจร, รถชน)
   ☐ 1.ไม่ทราบ ☐ 2.ไม่เคย
   ☐ 3.เคย (ระบุ)…………………………………………………………
12. เด็กมีความผิดปกติทางสายตาหรือไม่
   ☐ 1.ไม่มี ☐ 2.ไม่ทราบ/ไม่เคยตรวจ
   ☐ 3. สายตาสั้น ☐ 4. สายตายาว ☐ 5. สายตาเอียง
   ☐ 6. ตาบอดสี ☐ 7. อื่นๆ (ระบุ)………………………….

   หากเด็กมีปัญหาทางสายตา เด็กได้รับการแก้ไขหรือไม่

   ☐ 1.ไม่ได้รับการแก้ไข ☐ 2.ได้รับการแก้ไข (ระบุ)……………………

13. ตั้งแต่แรกเกิดจนถึงปัจจุบัน เด็กมีปัญหาด้านพฤติกรรมหรือไม่

☐ 1. ไม่มี ☐ 2. ซนอยู่ไม่นิ่ง

☐ 3. วอกแวกหรือหันเหความสนใจง่าย ☐ 4. ไม่รู้จักการรอคอย

☐ 5. เคลื่อนไหวซ้ำๆ ☐ 6. อื่นๆ (ระบุ)………………

14. ตั้งแต่แรกเกิดจนถึงปัจจุบัน เด็กมีปัญหาด้านการเคลื่อนไหวหรือไม่

☐ 1. ไม่มี ☐ 2. เดินไม่ตรง

☐ 3. เดินล้มบ่อยๆ ☐ 4. รับของมือเดียวไม่ได้

☐ 5. นั่งไม่ตรง ☐ 6. เดินซอยเท้า

☐ 7. อื่นๆ (ระบุ)…………………….

15. คุณคิดว่าที่ผ่านมาสุขภาพของเด็กเป็นอย่างไร

☐ 1.สุขภาพดีมาก (ไม่ค่อยป่วยหรือป่วยน้อยกว่า 2 ครั้ง/ปี)

☐ 2.สุขภาพดี (ป่วยบ้าง 2-4 ครั้ง/ปี)

☐ 3.สุขภาพไม่ค่อยดี (ป่วยบ่อย หรือมากกว่า 5 ครั้ง/ปี)

16. เด็กเคยมีอาการชักหรือไม่

☐ 1. ไม่เคย ☐ 2. เคย แต่ไม่ทราบสาเหตุ

☐ 3. เคย ทราบสาเหตุ (ระบุสาเหตุ, ระยะเวลาที่ชัก, มีอาการบ่อยหรือไม่เป็นต้น) ……………………………………………………………

17. โดยเฉลี่ยเด็กนอนหลับ (ในเวลากลางคืน)……………………ชั่วโมงต่อวัน

18. เด็กมีปัญหาในการนอนหลับหรือไม่

☐ 1. ไม่มี ☐ 2. หลับยาก

☐ 3. ตื่นบ่อยในเวลากลางคืน ☐ 4. นอนกรน

☐ 5. อื่นๆ (ระบุ)………………..

19. ขณะอยู่บ้านเด็กดื่มนมหรือไม่

1. ☐ ไม่ดื่ม 2. ☐ 1-2 กล่อง/วัน

3. ☐ 3-4 กล่อง/วัน 4. ☐ มากกว่า 5 กล่อง/วัน

20. เด็กมีโอกาสได้เรียนพิเศษเกี่ยวกับกิจกรรมต่างๆที่เพิ่มจากการเรียนการสอนในโรงเรียน

1. กิจกรรมส่งเสริมพัฒนาการ การฝึกการทรงตัว การฝึกเขียน การฝึกพูด

☐ 1.ไม่ได้รับ ☐ 2.ได้รับ (ระบุ)……………………

2. กิจกรรมทางด้านศิลปะ, เรียนวาดรูป, งานปั้น, ประดิษฐ์สิ่งของ

☐ 1.ไม่ได้รับ ☐ 2.ได้รับ (ระบุ)…………………….

3. กิจกรรมทางด้านวิชาการ

☐ 1.ไม่ได้รับ ☐ 2.ได้รับ (ระบุ)…………………….

4. กิจกรรมทางด้านกีฬา

☐ 1.ไม่ได้รับ ☐ 2.ได้รับ (ระบุ)………………………

5. กิจกรรมอื่นๆ (ระบุ)………………………………..…….

21. เด็กมีปัญหาด้านการเรียนหรือไม่

☐ 1.ไม่มี ☐ 2.มี ระบุ…………………………….

22. เด็กใช้เวลาทำกิจกรรมอะไรมากที่สุดเมื่ออยู่ที่บ้าน (เขียนเลขหน้าข้อความที่ตรงกับเด็กมากที่สุด เรียงจากมากไปหาน้อย 3 อันดับแรก)

☐ 1.วาดรูป/ระบายสี ☐ 2.ทำการบ้าน ☐ 3.ทำงานบ้าน

☐ 4.เล่นกับเพื่อน ☐ 5.เล่นดนตรี ☐ 6.เล่นกีฬา (ระบุ)…………….

☐ 7.เล่นตุ๊กตา/หุ่นยนต์ ☐ 8.ขี่จักรยาน ☐ 9.ปั้นดินน้ำมัน/งานปั้น

☐ 10.ประดิษฐ์สิ่งของ ☐ 11.อื่นๆ (ระบุ)………………………………………

23. เด็กดูโทรทัศน์หรือไม่

☐ 1. ไม่ดู (ข้ามไปข้อ 27)

☐ 2. ดู

24. เด็กดูโทรทัศน์กับใคร

☐ 1. ดูโดยลำพัง

☐ 2. ดูโดยพ่อแม่ดูด้วย

☐ 3. ดูกับบุคคลอื่น ระบุ………………………

25. เด็กดูโทรทัศน์เฉลี่ยวันละกี่ชั่วโมง (เฉลี่ยรวมวันธรรมดาและวันหยุดเสาร์-อาทิตย์)

1. ☐ น้อยกว่า 1 ชม. 2. ☐ 1-2 ชม.

3. ☐ 2-3 ชม. 4. ☐ 3-4 ชม.

5. ☐ มากกว่า 4 ชม.

26. ประเภทรายการโทรทัศน์ที่เด็กดู โปรดระบุ …………………………………………

27. เด็กเล่นคอมพิวเตอร์/แทปเลท/เกมส์ หรือไม่

☐ 1. ไม่เล่น (ข้ามไปข้อ 29)

☐ 2. เล่น

28. เด็กเล่นคอมพิวเตอร์/แทปเลท/เกมส์ วันละกี่ชั่วโมง (เฉลี่ยรวมวันธรรมดาและวันหยุดเสาร์-อาทิตย์)

1. ☐ น้อยกว่า 1 ชม. 2. ☐ 1-2 ชม.

3. ☐ 2-3 ชม. 4. ☐ 3-4 ชม.

5. ☐ มากกว่า 4 ชม.

29. ข้อควรปรับปรุงเกี่ยวกับบุตรหลานของท่าน มีอะไรบ้าง

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

ขอขอบพระคุณในการให้ความร่วมมือ

นางสาว กฤติยาณี ธรรมสาร

APPENDIX F
THE BEERY-BUKTENICA DEVELOPMENT TEST OF VISUAL-MOTOR INTEGRATION (VMI) 6TH EDITION

VISUAL-MOTOR INTEGRATION

The Beery–Buktenica
Developmental Test of Visual–Motor Integration

Beery™ VMI Sixth Edition

Ages 2 through 100 (FULL FORM)

by Keith E. Beery, Norman A. Buktenica, and Natasha A. Beery

Name: ______________ (Last) ______________ (First) Sex: ○ F ☐ M
School: ______________ Grade: ______
Examiner: ______________
Test Date: ____ year ____ month ____ day
Birth Date: ____ year ____ month ____ day
Chronological Age: ____ year ____ month
(Count more than 15 days as one month.)

SUMMARY

See the Beery VMI manual (sixth edition) for norms.

	Beery VMI	Visual Perception	Motor Coordination
Raw Scores:	___	___	___
Standard Scores:	___	___	___
Scaled Scores:	___	___	___
Percentiles:	___	___	___
Other Scaling:	___	___	___

Comments and Recommendations:

PROFILE

Standard Score	Beery VMI	Visual Perception	Motor Coordination	Percentile
145	-	-	-	99.7
140	-	-	-	99.2
135	-	-	-	99
130	-	-	-	98
125	-	-	-	95
120	-	-	-	91
115	-	-	-	84
110	-	-	-	75
105	-	-	-	63
100	-	-	-	50
95	-	-	-	37
90	-	-	-	25
85	-	-	-	16
80	-	-	-	9
75	-	-	-	5
70	-	-	-	2
65	-	-	-	1
60	-	-	-	.8
55	-	-	-	.3

Begin testing on page 1. Turn booklet over with bound edge toward the examinee. If subtests are used, always test in this order: VMI → Visual → Motor.

PEARSON

PsychCorp

Product Number 46240/46241

THIS SIDE UP

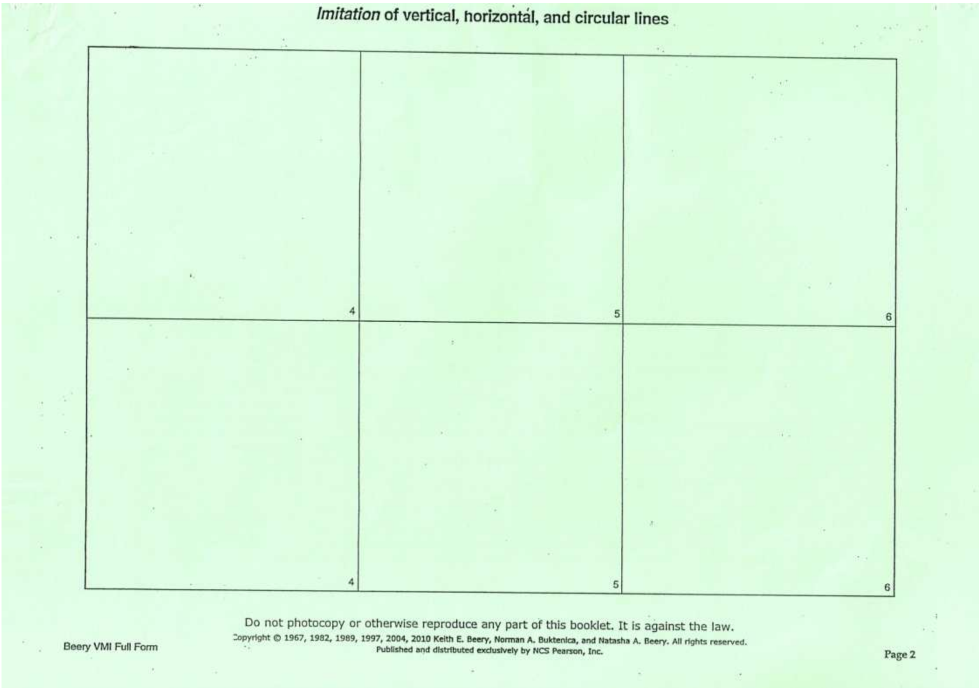
Let's Draw!

Use a No. 2 pencil (or another pencil with soft black lead) or a ballpoint pen with black ink.
Remember, you get one try with no erasing.
Keep the booklet straight in front of you and don't tilt it.
Just do the best you can on both the easy ones and the hard ones.
Don't skip any!
When asked to do so, please turn the page from the top to begin.

THIS SIDE UP

Items 1–6 are for children; credit for adult if Item 7 is answered correctly.
Items 1–3: Marking and Scribbling
- Use the boxes below for Items 1–3 only if necessary for immature children. Refer to the administration directions for these items ("Individual Children Under Functional Age 5") in chapter III of the Beery™ VMI manual (sixth edition).
- If there are marks below, which box contains the child's marks: ___ left side or ___ right side?
  Were the child's marks: ___ spontaneous or ___ imitated?
- For scoring directions, refer to the "Marking and Scribbling" section in chapter III of the Beery VMI manual (sixth edition).

Beery VMI Full Form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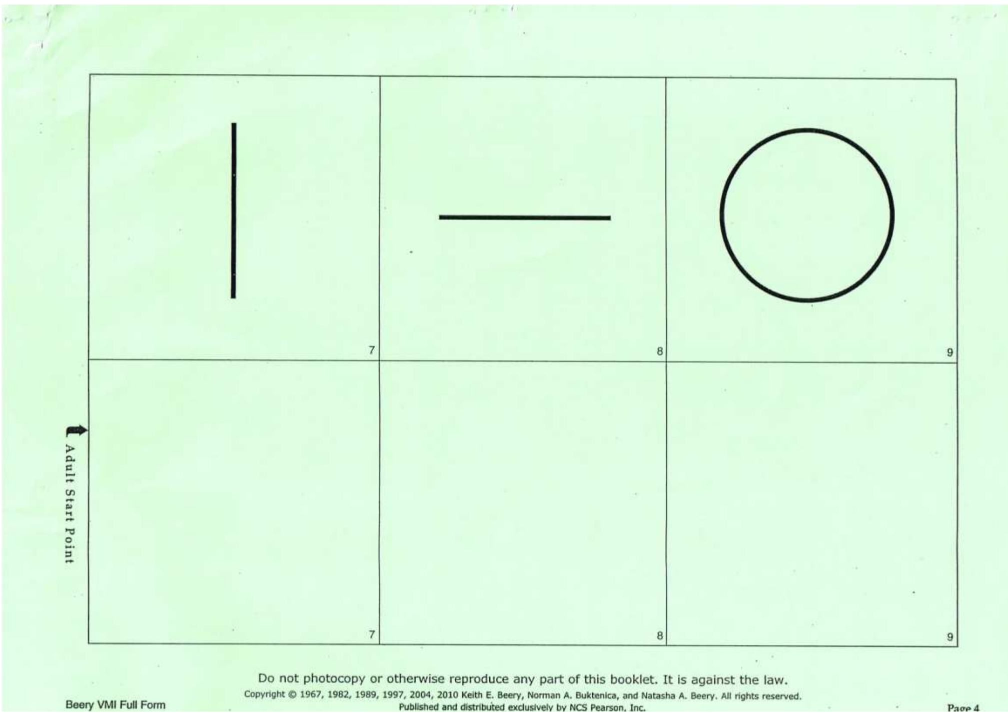
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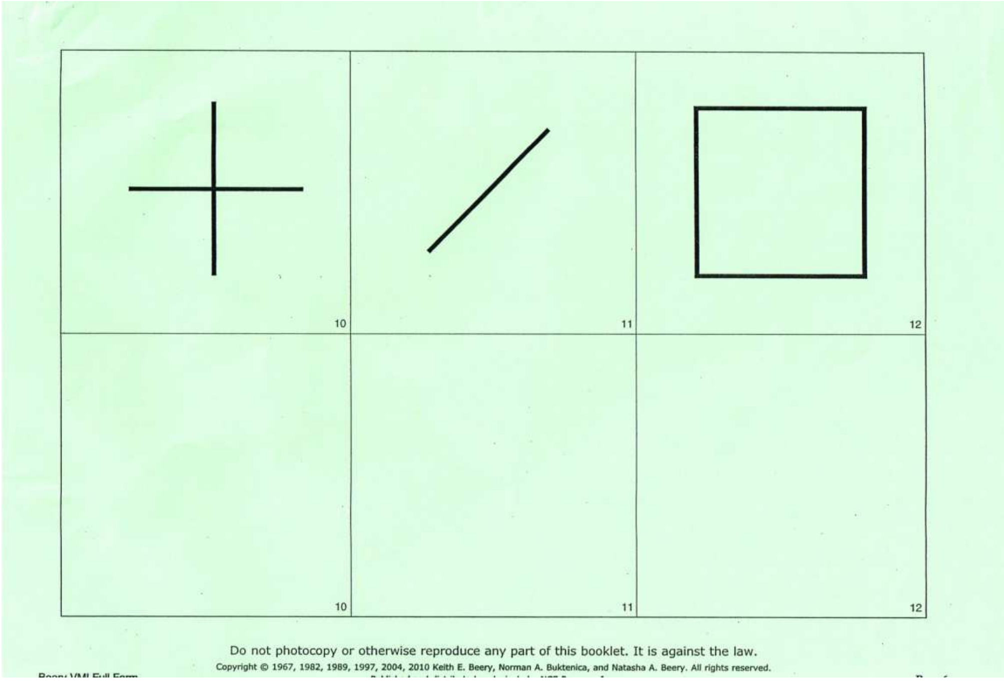
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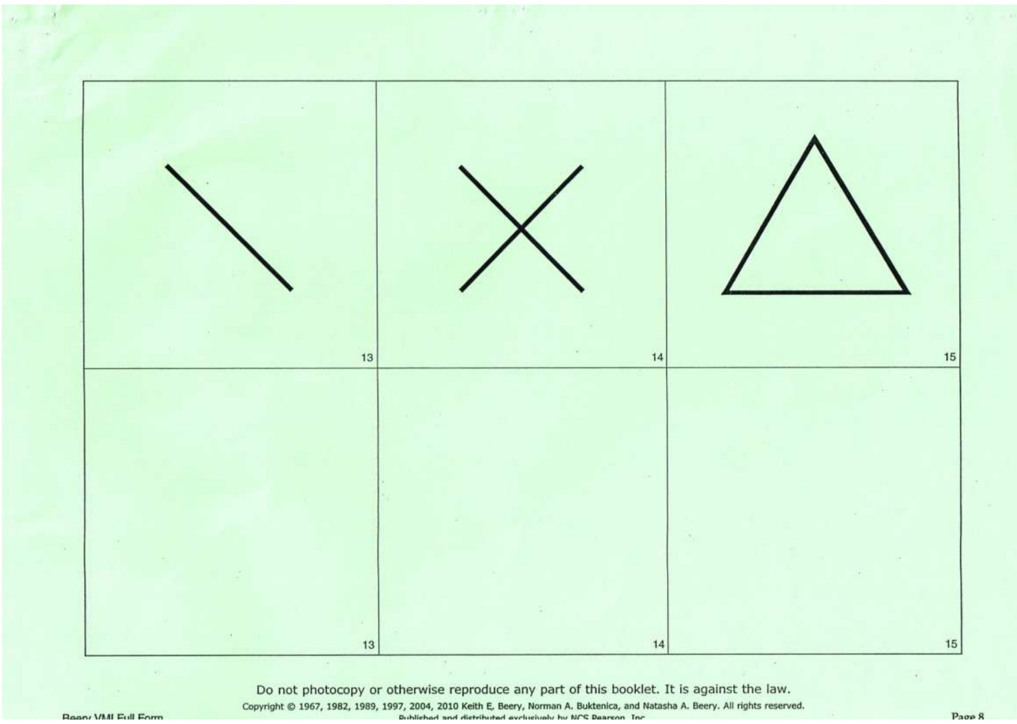
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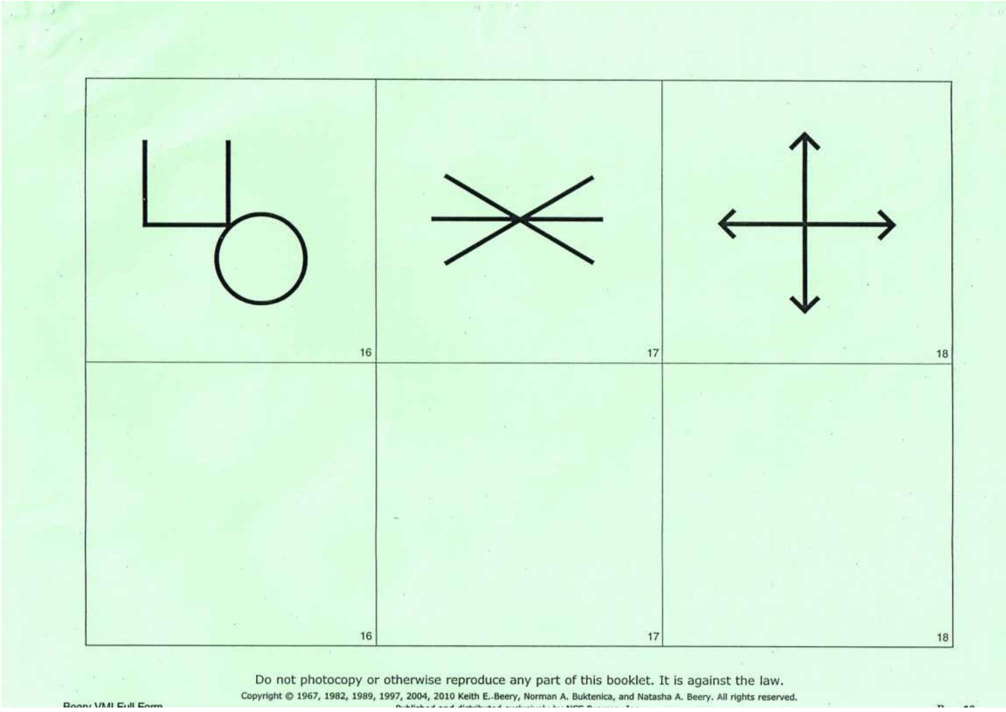
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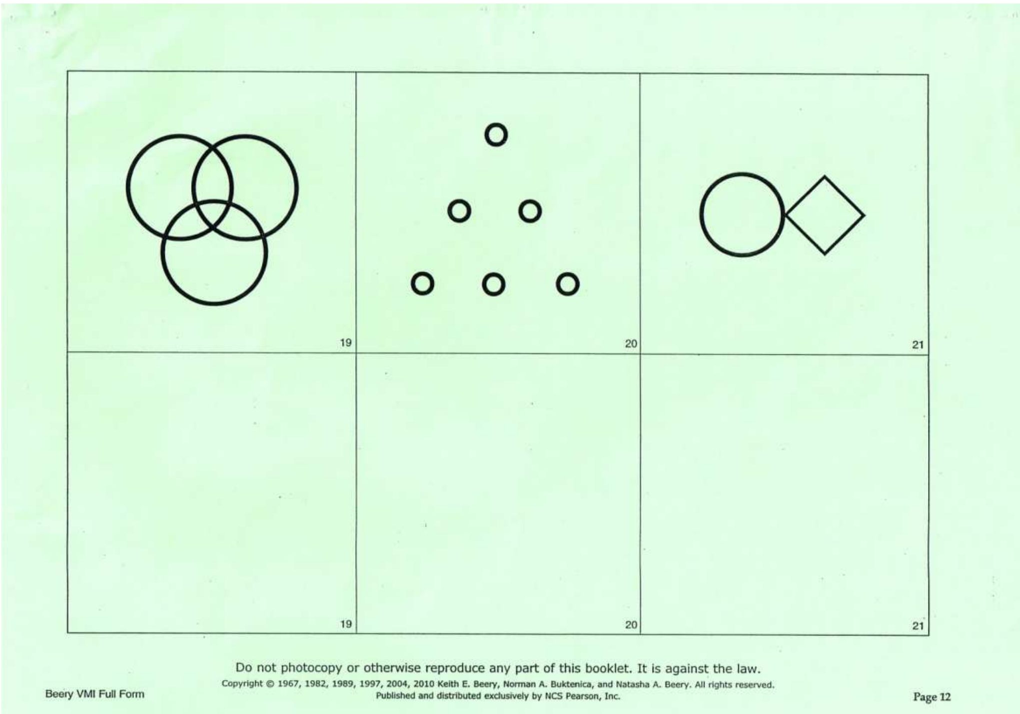
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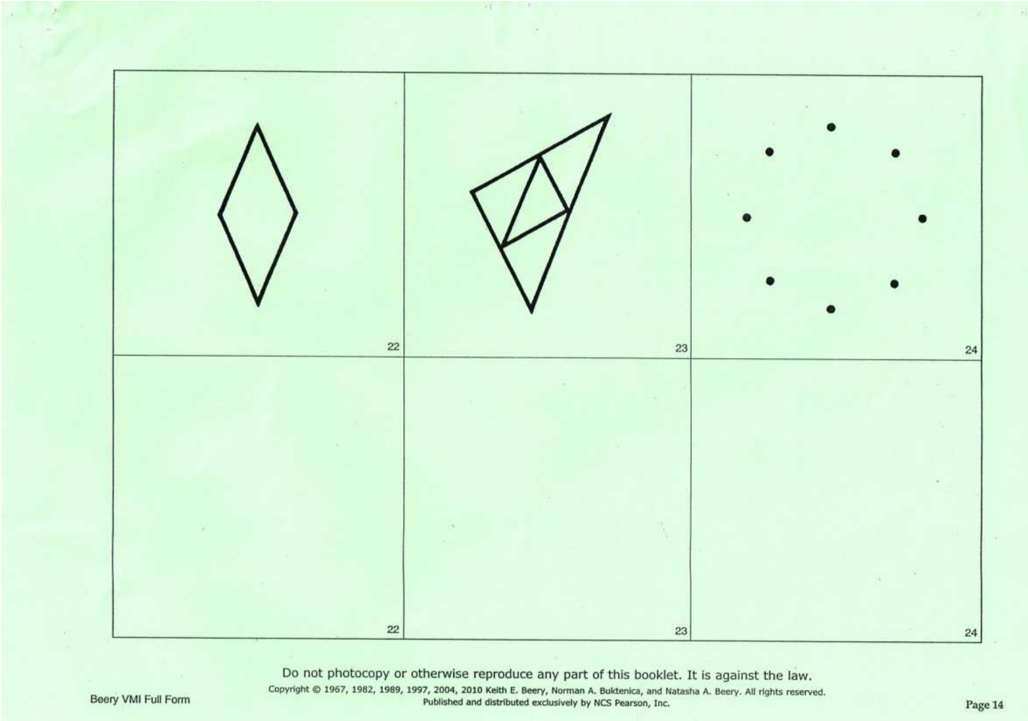
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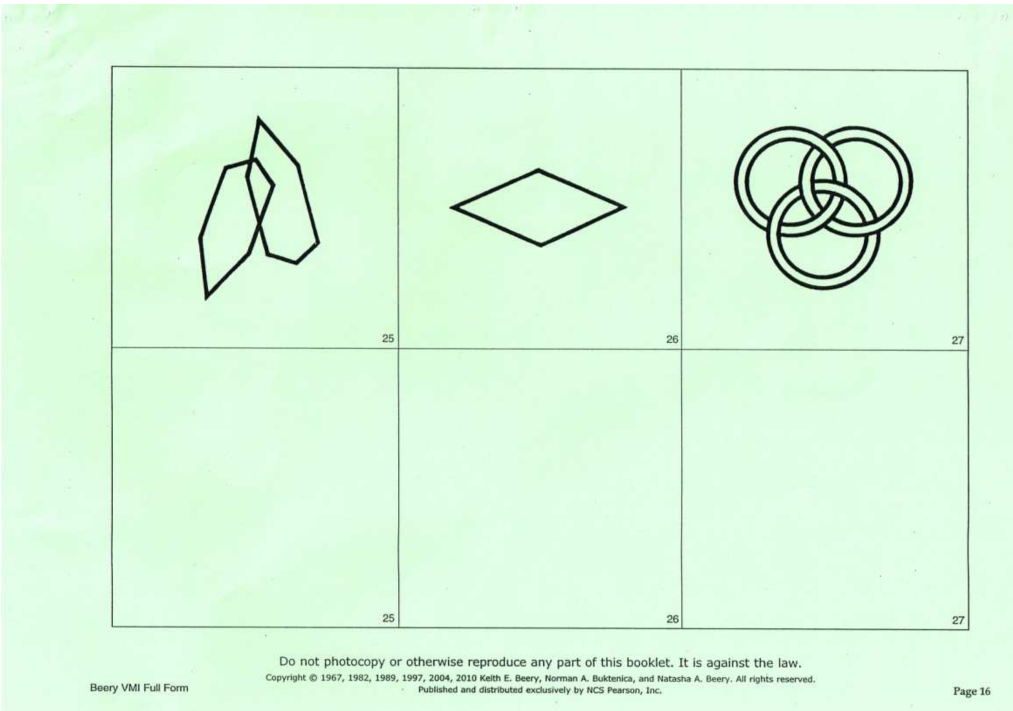
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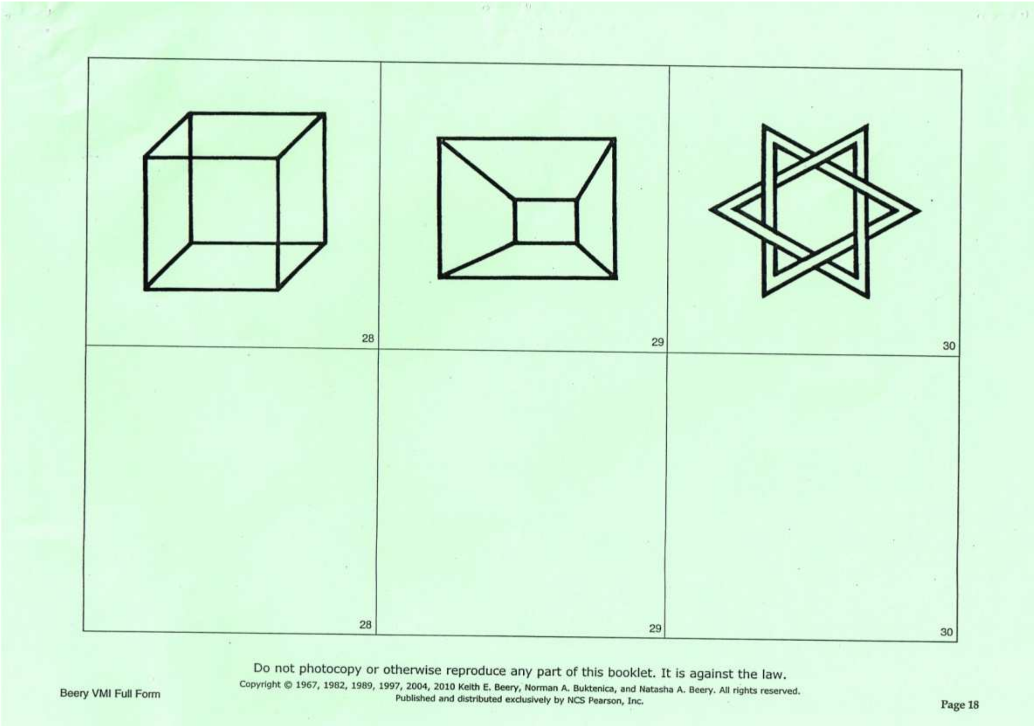
Beery VMI Full Form
Page 16



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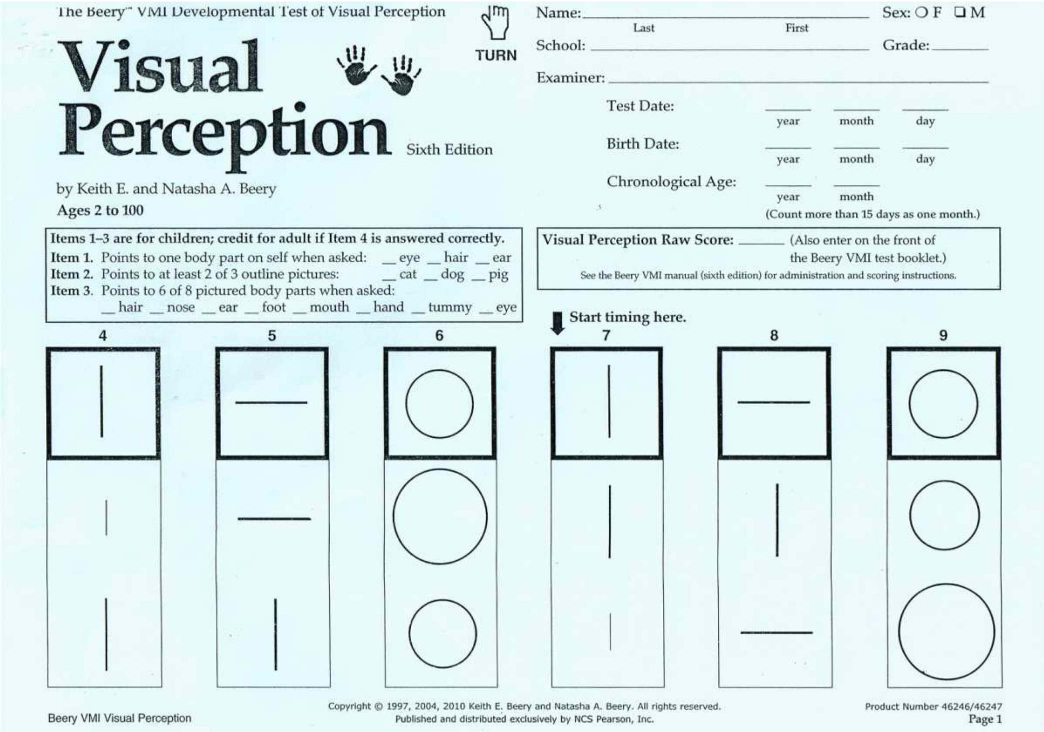
Page 18

VISUAL PERCEPTION


The Beery™ VMI Developmental Test of Visual Perception

Visual Perception

Sixth Edition

by Keith E. and Natasha A. Beery

Ages 2 to 100

TURN

Name: ______ Last ______ First ______ Sex: ○ F ❑ M

School: ______ Grade: ______

Examiner: ______

Test Date: ___ year ___ month ___ day

Birth Date: ___ year ___ month ___ day

Chronological Age: ___ year ___ month

(Count more than 15 days as one month.)

Items 1–3 are for children; credit for adult if Item 4 is answered correctly.

Item 1. Points to one body part on self when asked: __ eye __ hair __ ear

Item 2. Points to at least 2 of 3 outline pictures: __ cat __ dog __ pig

Item 3. Points to 6 of 8 pictured body parts when asked: __ hair __ nose __ ear __ foot __ mouth __ hand __ tummy __ eye

Visual Perception Raw Score: ______ (Also enter on the front of the Beery VMI test booklet.)

See the Beery VMI manual (sixth edition) for administration and scoring instructions.

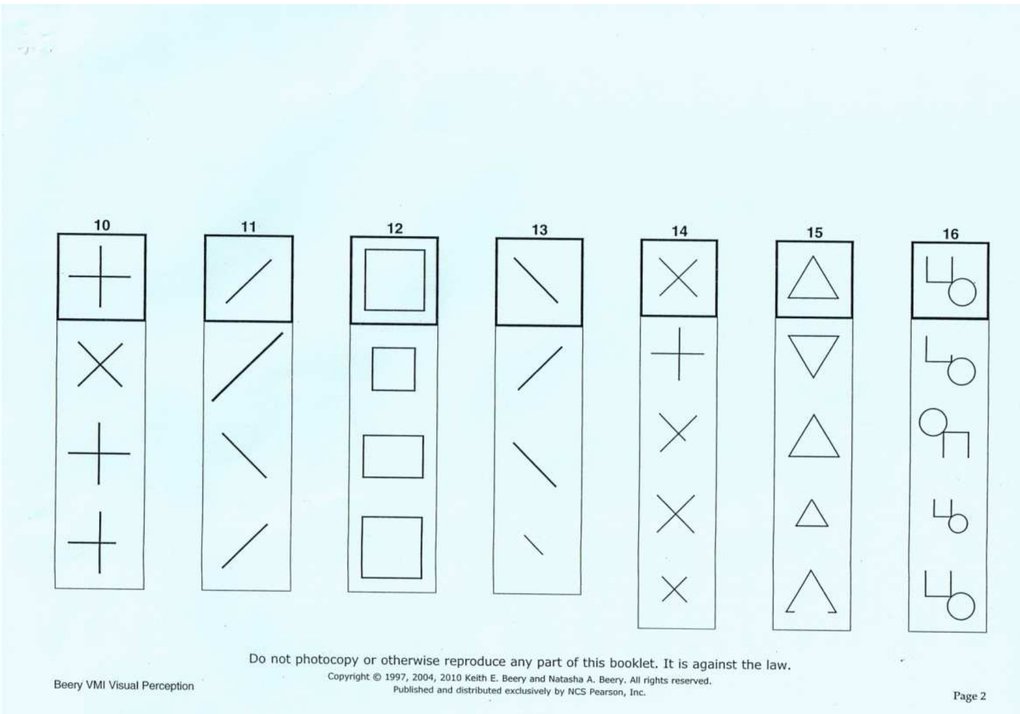
Start timing here.

4 5 6 7 8 9

Beery VMI Visual Perception

Product Number 46246/46247

Page 1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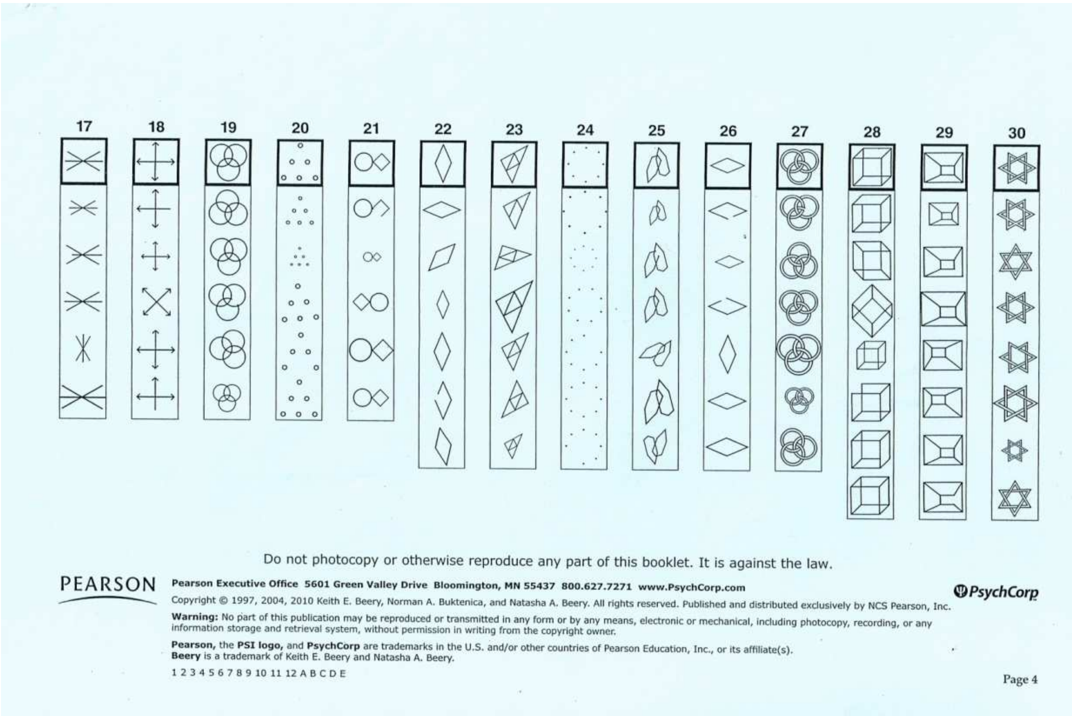
Beery VMI Visual Perception

Page 2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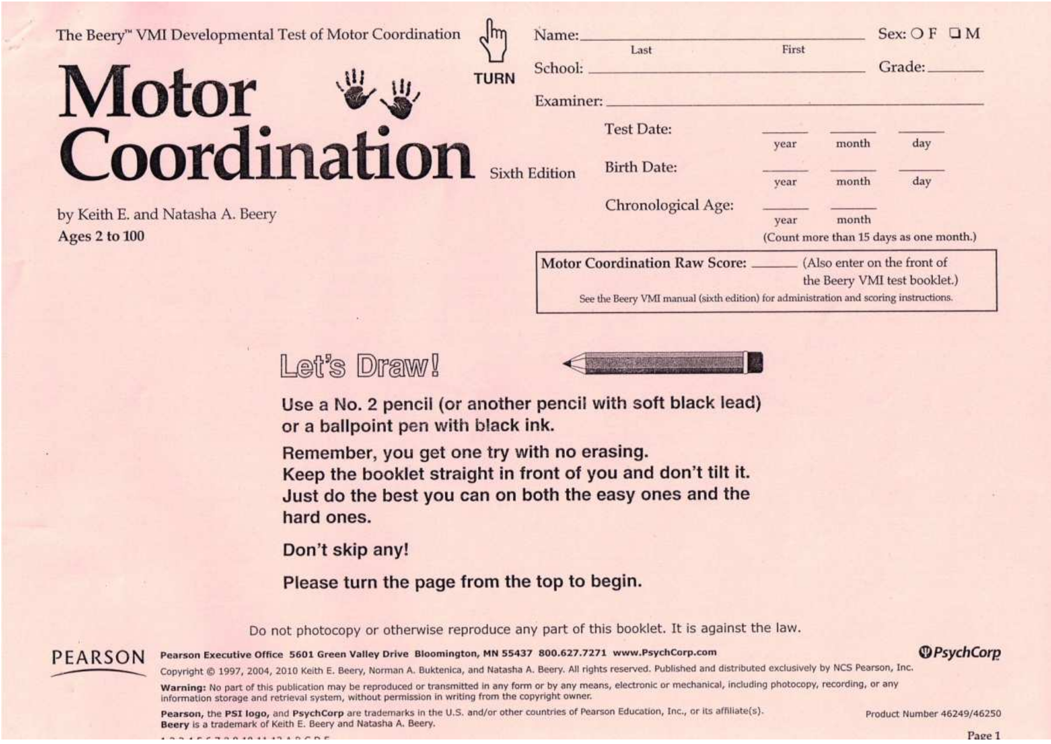
Page 4

MOTOR COORDINATION



The Beery™ VMI Developmental Test of Motor Coordination

TURN

Motor Coordination

Sixth Edition

by Keith E. and Natasha A. Beery

Ages 2 to 100

Name: ______ Last ______ First ______ Sex: ○ F ☐ M

School: ______ Grade: ______

Examiner: ______

Test Date: ______ year ______ month ______ day

Birth Date: ______ year ______ month ______ day

Chronological Age: ______ year ______ month

(Count more than 15 days as one month.)

Motor Coordination Raw Score: ______ (Also enter on the front of the Beery VMI test booklet.)

See the Beery VMI manual (sixth edition) for administration and scoring instructions.

Let's Draw!

Use a No. 2 pencil (or another pencil with soft black lead) or a ballpoint pen with black ink.

Remember, you get one try with no erasing.

Keep the booklet straight in front of you and don't tilt it.

Just do the best you can on both the easy ones and the hard ones.

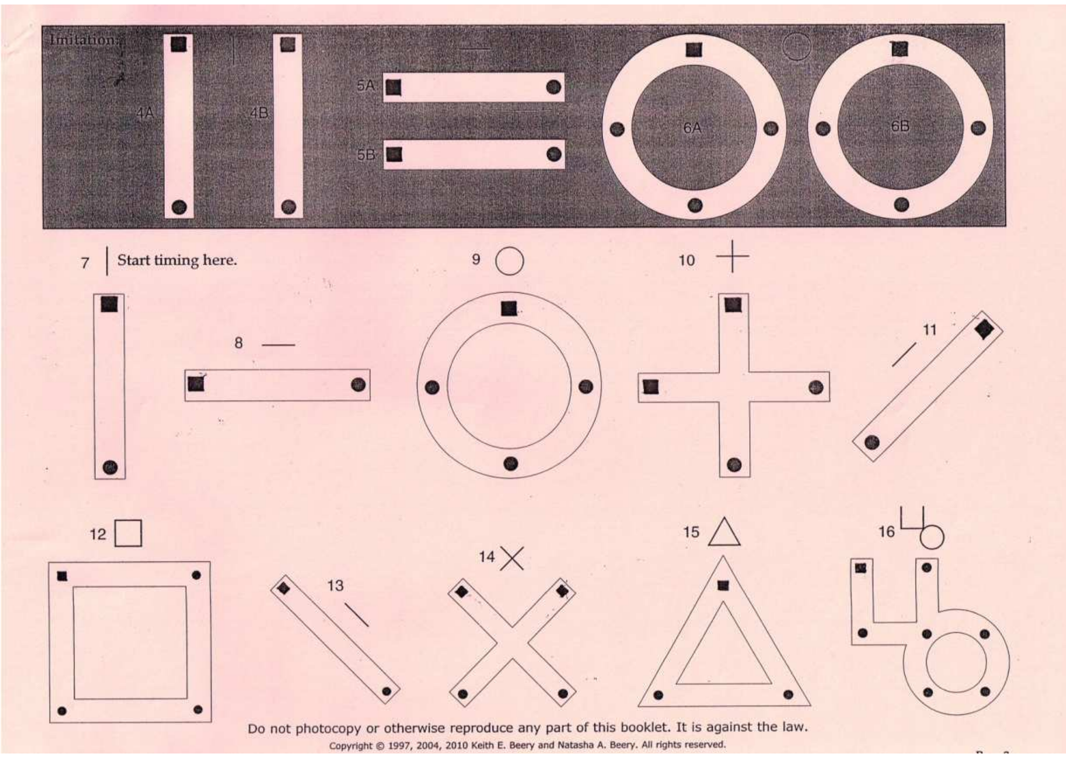
Don't skip any!

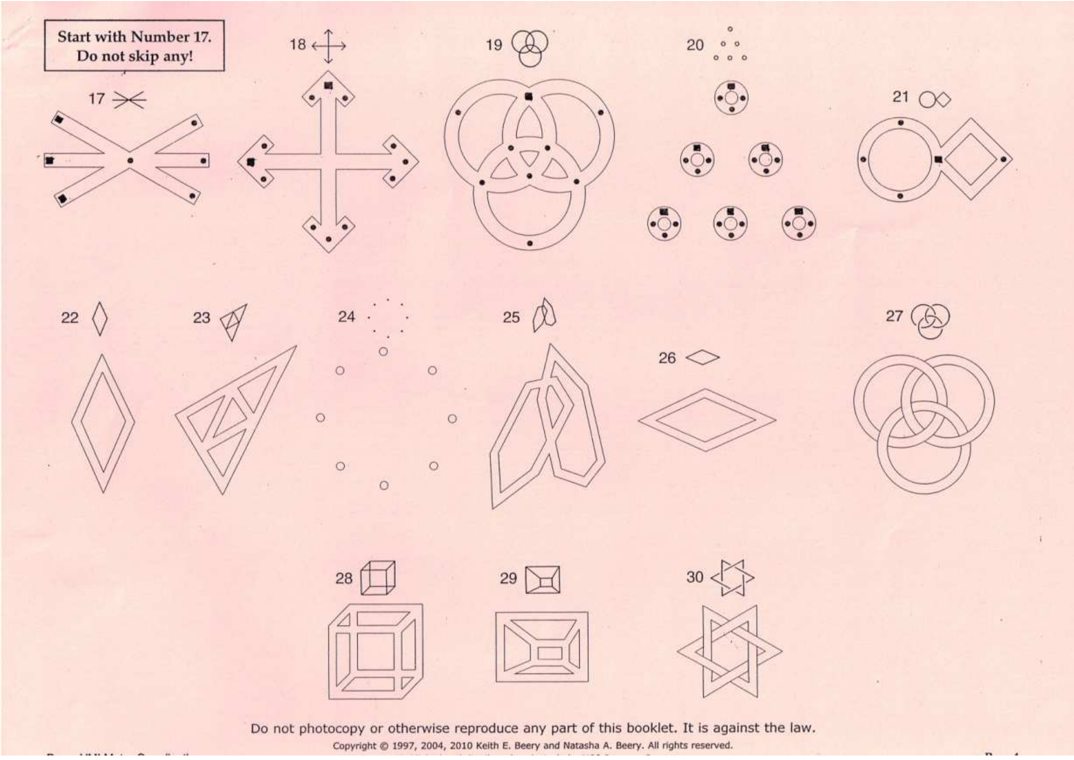
Please turn the page from the top to begin.

PEARSON **Pearson Executive Office 5601 Green Valley Drive Bloomington, MN 55437 800.627.7271 www.PsychCorp.com** PsychCorp

Product Number 46249/46250

Page 1




Start with Number 17.
Do not skip any!
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APPENDIX G
THE TASK OF EXECUTIVE CONTROL (TEC)

TEC เป็นโปรแกรมคอมพิวเตอร์ มีพื้นฐานมาจากการประเมินในคลินิก cognitive neuroscience ที่มีประโยชน์ใช้ในการประเมิน working memory กับ Inhibitory control ในเด็ก อายุ 5-18 ปี

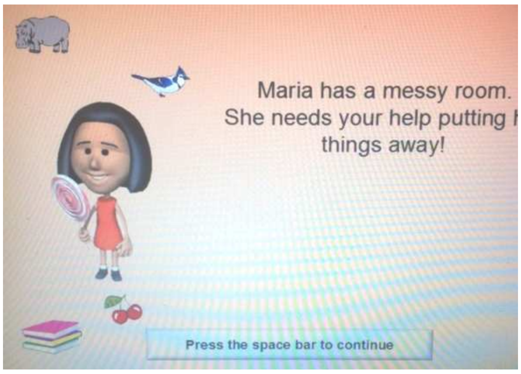
การทดสอบแบ่งออกเป็น

N-Back ใช้ประเมิน Working memory โดยแบ่งออกเป็น 3 task ย่อยคือ

- 0-Back
- 1-Back
- 2-Back

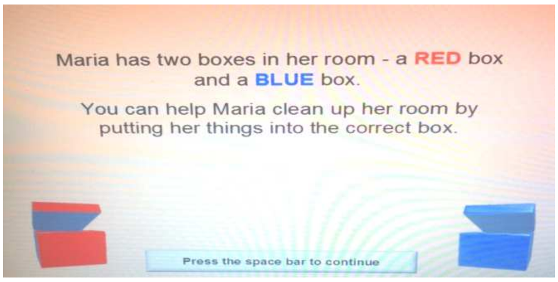
Go/No-Go ใช้ประเมิน Inhibitory control

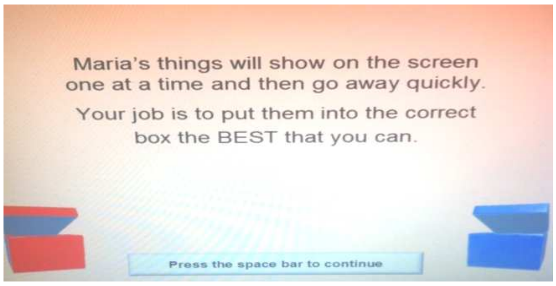
ก่อนการทดสอบ โปรแกรมจะให้เด็กกรอก Code และวัน/เดือน/ปีเกิด เพื่อที่โปรแกรมจะคำนวณอายุและจัดระดับความยากง่ายของแบบทดสอบตามอายุเด็ก

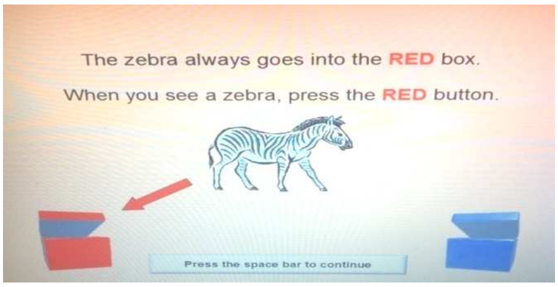


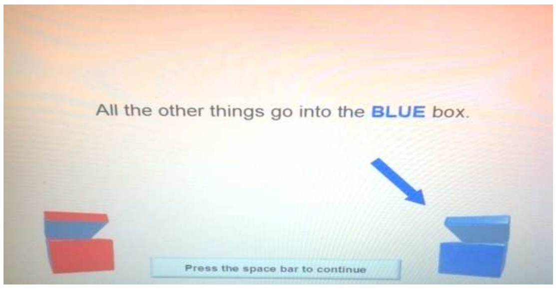
เริ่มต้นการทดสอบ แบบทดสอบจะมีลักษณะเป็นเกมส์คอมพิวเตอร์ โดยใช้รูปแบบการจำภาพสิ่งของ จากการช่วยตัวการ์ตูนที่ชื่อ "มาเรีย" จัดห้องที่รกอยู่ โดยการนำสิ่งของใส่ในกล่องให้ถูกต้องตามคำสั่ง

<u>ระดับที่ 1 : 0-Back / No Inhibit (target=Zebra)</u>



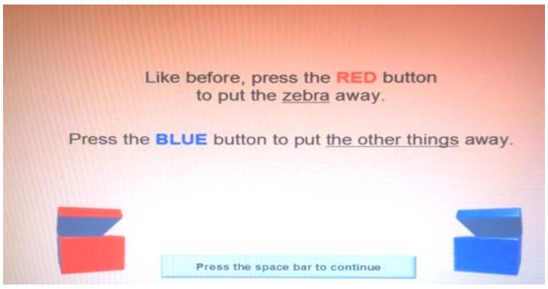


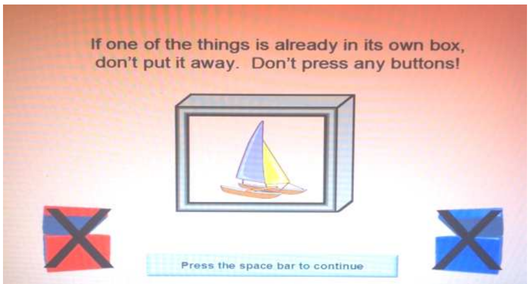




มาเรียจะมีกล่อง 2 กล่องอยู่ในห้อง คือ กล่องสีแดง และกล่องสีน้ำเงิน โดยเด็กที่ทดสอบต้องกดคีย์บอด ในปุ่มที่กำหนดแทนกล่องสีแดง คือ Shift ทางซ้าย และปุ่มที่กำหนดแทนกล่องสีน้ำเงินคือ Shift ทางขวา โปรแกรมกำหนด target คือม้าลาย โดยถ้ารูปปรากฏบนหน้าจอเป็นรูปม้าลาย ต้องกดคีย์บอดแทนกล่องสีแดง และหากรูปอื่นๆปรากฏบนหน้าจอต้องกดคีย์บอดแทนกล่องสีน้ำเงิน และก่อนการทดสอบจริงทุกครั้ง โปรแกรมจะให้ลองทดสอบเพื่อความเข้าใจก่อน ซึ่งหากเด็กที่เข้าใจและสามารถทำแบบลองทดสอบได้ถูกต้อง โปรแกรมจึงจะเริ่มทำการทดสอบจริง แต่ถ้าหากเด็กยังทำแบบลองทดสอบไม่ผ่าน โปรแกรมจะถือว่าเด็กยังคงไม่เข้าใจ และจะให้ลองทำแบบทดสอบจนกว่าเด็กจะเข้าใจ แล้วจึงทำการเริ่มการทดสอบจริง

0-Back / Inhibit (target=Zebra)





ระดับถัดมา จาก 0-Back / No Inhibit (target=Zebra) คือ การเพิ่มการ Inhibit มาใช้ในการทดสอบ โดยคำสั่งยังคงเหมือนเดิม คือ มาเรียจะมีกล่อง 2 กล่องอยู่ในห้อง คือ กล่องสีแดง และกล่องสีน้ำเงิน โดยเด็กที่ทดสอบต้องกดคีย์บอด ในปุ่มที่กำหนดแทนกล่องสีแดง คือ Shift ทางซ้าย และปุ่มที่กำหนดแทนกล่องสีน้ำเงินคือ Shift ทางขวา โปรแกรมกำหนด target คือม้าลาย โดยถ้ารูปปรากฏบนหน้าจอเป็นรูปม้าลาย ต้องกดคีย์บอดแทนกล่องสีแดง และหากรูปอื่นๆ ปรากฏบนหน้าจอต้องกดคีย์บอดแทนกล่องสีน้ำเงิน แต่จะเพิ่มรูปกล่องสี่เหลี่ยม ซึ่งหากรูปกล่องสี่เหลี่ยมปรากฏบนหน้าจอ หมายถึงเด็กต้องห้ามกดปุ่มใดๆ

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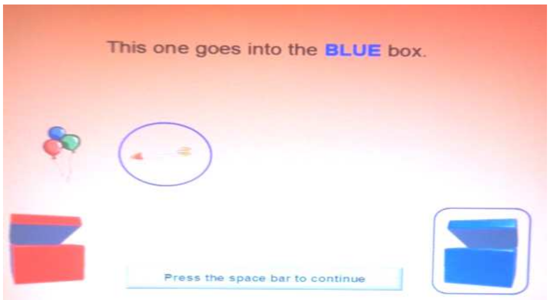
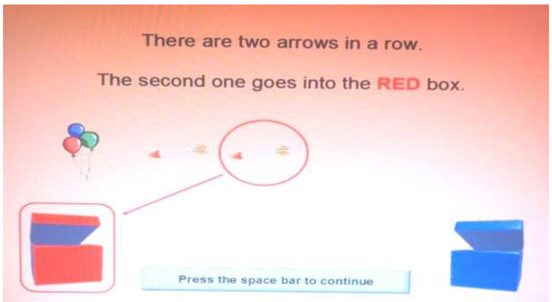
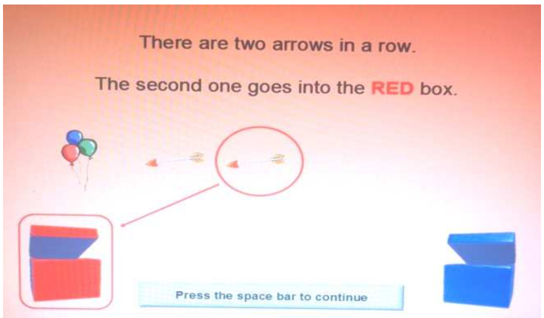




ระดับที่ 2 มาเรียจะมีกล่อง 2 กล่องอยู่ในห้อง คือ กล่องสีแดง และกล่องสีน้ำเงิน โดยเด็กที่ทดสอบต้องกดคีย์บอด ในปุ่มที่กำหนดแทนกล่องสีแดง คือ Shift ทางซ้าย และปุ่มที่กำหนดแทนกล่องสีน้ำเงินคือ Shift ทางขวา โปรแกรมกำหนดรูปที่ปรากฏบนหน้าจอทุกรูป ให้กดคีย์บอดแทนกล่องสีน้ำเงิน แต่หากรูปใดที่ปรากฏบนหน้าจอซ้ำกับรูปก่อนหน้า ต้องกดคีย์บอดแทนกล่องสีแดง

1-Back / Inhibit



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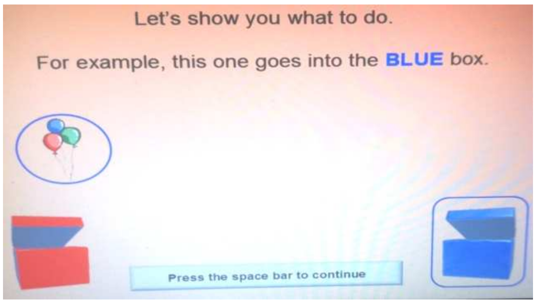

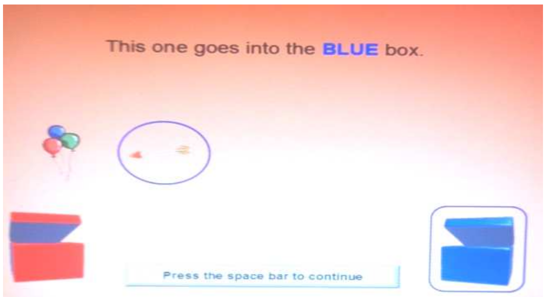

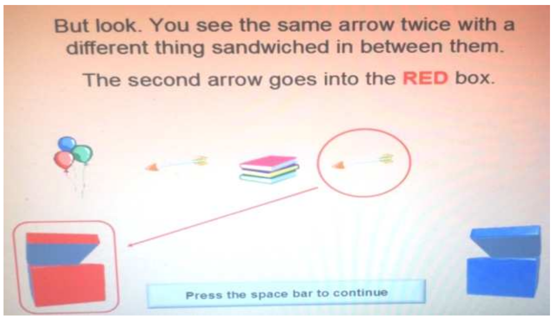

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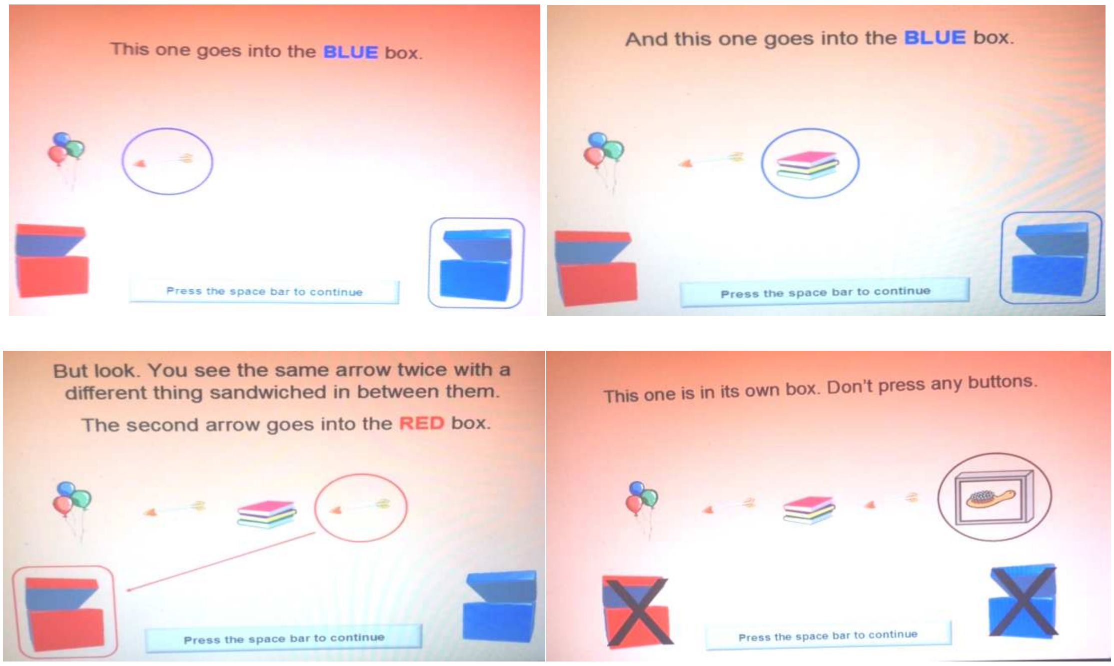
2-Back / Inhibit



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BIOGRAPHY

NAME	Miss Krittiyanee Thammasarn
DATE OF BIRTH	11 July 1990
PLACE OF BIRTH	Nakhonratchasima, Thailand
INSTITUTIONS ATTENDED	The Thai Red Cross College of Nursing, 2008-2011 Bachelor of Nursing Science (B.N.S.) Mahidol University, 2012-2013 Master of Science (Human Development)
RESEARCH GRANTS	Partial supported the thesis Grant Faculty of Graduate Studies, Mahidol University
HOME ADDRESS	27 M.7 Prathai, Nakhonratchasima, 30180, Thailand Tel. +66 83-545-6546 Email: chubby_moonoi@hotmail.com
PRESENTATION	The 2nd ASEAN Plus Three Graduate Research Congress 5th - 7th February 2014 Bangkok, Thailand