ความบกพร่องของกลยุทธ์การประมวลผลข้อมูลขณะทำกิจกรรมการเล่น ในเด็กไทยที่มีความบกพร่องทางการเรียนรู้

Information processing strategy dysfunctions during the play activities in Thai children with learning disabilities

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บทคัดย่อ

บทนำ: เด็กที่มีความบกพร่องทางการเรียนรู้มักมีความบกพร่องในการประมวลผลข้อมูลซึ่งเป็นอุปสรรคต่อการมีส่วนร่วมในกิจกรรมต่างๆ ของโรงเรียน

วัตถุประสงค์: เพื่อสำรวจความบกพร่องของเด็กไทยที่มีความบกพร่องทางการเรียนรู้การใช้กลยุทธ์ในการประมวลข้อมูลขณะทำกิจกรรมการเล่น 3 ประเภท โดยมีแบบประเมิน พีอาร์พีพี ซิสเต็ม ฉบับภาษาไทย ซึ่งเป็นแบบประเมินอ้างอิงเกณฑ์และเน้นการประเมินขณะทำกิจกรรมเป็นเครื่องมือ พีอาร์พีพี ซิสเต็ม ฉบับภาษาไทย เป็นแบบประเมินความคิดความเข้าใจตามขั้นตอนการประมวลผลข้อมูล 4 ขั้นตอน ได้แก่ การรับรู้ความรู้สึก (perceive quadrant) ความจำ (recall quadrant) การตอบสนองต่อการวางแผนและการประเมินผล (plan quadrant) และการติดตามการกระทำ (perform quadrant)

วิธีการศึกษา: เด็กที่มีความบกพร่องทางการเรียนรู้จำนวน 30 ราย ถูกประเมินโดยใช้แบบประเมินพีอาร์พีพีซิสเต็ม ฉบับภาษาไทย ระหว่างทำกิจกรรมการเล่น 3 ประเภท ได้แก่ เกมความคิดความเข้าใจ กิจกรรมการเคลื่อนไหว และเกมการแข่งขัน วิเคราะห์ข้อมูลโดยใช้สถิติเชิงพรรณนา

ผลการศึกษา: กลุ่มตัวอย่างมีความบกพร่องในการใช้กลยุทธ์เพื่อประมวลผลข้อมูลในกิจกรรมการเล่นทั้ง 3 ประเภท โดยการตอบสนองต่อการวางแผนและการประเมินผล (plan quadrant) เป็นกระบวนการที่มีปัญหามากที่สุด ในขณะที่ความจำ (recall quadrant) พบความบกพร่องน้อยที่สุด

สรุปผลการศึกษา: กลุ่มตัวอย่างเด็กไทยที่มีความบกพร่องทางการเรียนรู้มีความบกพร่องในการใช้กลยุทธ์เพื่อประมวลผลข้อมูลระหว่างการทำกิจกรรมการเล่นที่ประเมินโดยแบบประเมินพีอาร์พีพี ซิสเต็มฉบับภาษาไทย

วารสารเทคนิคการแพทย์เชียงใหม่ 2559; 49(1): 17-35. Doi: 10.14456/jams.2016.15

คำหัส: กลยุทธ์การประมวลผลข้อมูล พีอาร์พีพี ซีสเต็มฉบับภาษาไทย เด็กที่มีความบกพร่องทางการเรียนรู้ กิจกรรมการเล่น

Abstract

Introduction: Children with learning disabilities (LD) have difficulties in information processing strategies that interfere with participating in school activities.

Objective: To explore information processing strategy dysfunctions on 3 play activities in Thai children with learning disabilities based on the PRPP system of task analysis (PRPP System): Thai version. PRPP was a criterion-referenced, occupation-focused assessment. The PRPP system assesses cognitive abilities corresponding to four stages of information processing; sensory perception (perceive quadrant), memory (recall quadrant), response planning and evaluation (plan quadrant), and performance monitoring (perform quadrant).

Methods: Thirty children with LD were assessed using the PRPP System: Thai version during the performance of 3 play activities including cognitive games, movement activities, and competitive plays. Data were analyzed using descriptive statistics.

Results: Analysis of the performance demonstrated that participants had difficulties in all stages of the information processing in the all 3 play activities. In addition, plan quadrant produced the most problems while recall quadrant was reported to be the least problematic.

Conclusion: Thai children with LD demonstrated problems in all stages of information processing during the performance of play activities assessed by the PRPP System: Thai Version.

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Keywords: Information processing strategies; PRPP system: Thai version; children with learning disabilities; play activities

Introduction

Children with learning disabilities (LD) have difficulties in four stages of information processing used in learning including input, integration, storage, and output.[1] These difficulties can interfere with learning basic skill and higher level skill. Learning disabilities have impact on both academics and relationships with family, friends and in workplace.[2] This information conforms to contemporary occupational therapy practice. There is rising awareness that information processing problems exist in children with learning disabilities and that these problems impact on occupational performance at home and school.[3] Deficits in information processing ability can consequently occur at any stage in this four-part process.[4] Each child will have a unique pattern of LD related with specific information disorders that many affect brain's ability to perceive, integrate, store and communicate information. For example, those who have difficulty in perceiving information may have problems in recognizing shape, position and size of the items seen. Those who have difficulty in integrating information may have problems in placing information in the proper order. Those who have difficulty in storing and placing information processing may have problems in memorizing or learning new materials. Those who have difficulty in communicating information may have problems in answering questions, or face difficulties with motor abilities. Besides, the inability to process information efficiently can lead to frustration, social incompetence,

low self-esteem, and language impairments.[5] Moreover, Learner also described that children with LD display problems about knowing the way to increase their knowledge, the way to organize and regulate their thinking, the way to incorporate new matter with past experiences and knowledge already acquired, the way to remember what they learn, and the way to approach tasks purposefully.[6] Many researchers were interested in information processing on children with LD. However, they had focused on different aspects of information processing, and employed different research instruments and methodologies.[7-9] For instances, Watson and Willows examined the potential contribution of a range of processing factors to reading success and failure at early and later stages of reading development by using the Goldman-Fristoe-Woodcock (G-F-W) sound-symbol tests, clinical evaluation of language functions, WISC-R, developmental test of visual-motor integration, test of visual-perceptual skills, G-F-W sound-symbol tests, Gates-McKillop reading diagnostic tests, wide range achievement test-revised, and rapid automatized naming test.[7] Result demonstrated that children who had reading disability were characterized by difficulty in what was interpreted as symbolic processing/memory, which occurred in combination with visual processing deficiencies and with deficits in both visual processing and rapid automatized naming. On the other hand, Cermak investigated the ability of learning disabled children to process, retain, and retrieve verbal information within a series of information-processing tasks in children with LD by using the repetitive task, the phonemic (rhyming) task, the semantic (category) task, and the single-letter-only task.[8] The result revealed that both rate and level at which these children process information were below the standards set by normal children. Taken together, these researches highlighted the same conclusion that information processing disorder was a crucial problem in children with LD.[7-9]

Since assessment is a vital step of an occupational therapy process for implementing an effective intervention, the assessment method of information processing strategy dysfunction are presented in this article. In the area of cognitive intervention, there is an increasing need of an occupation-focused assessment tool to identify and explain how cognitive deficits interfere with daily task accomplishment in clients with cognitive dysfunction including children with LD. In addition, this instrument helps to establish strength and weakness in the cognitive processing strategies that are required to execute these critical activities. Occupation-focused assessment has been recommended by therapists to measure cognitive disorder since it considers real-world situations that could lead to greater individualization of treatment plans, and thus to a more efficient therapy outcome.[10] The perceive, recall, plan and perform (PRPP) system of task analysis is one of the occupation-focused assessments that measures both task performance skills and cognitive information processing strategy over time in a specific context.[11] It is composed of two analyzing stages. Stage one analysis employed a standard behavioral task analysis to indicate the person's mastery for specific and relevant occupations. Stage two analysis adopts a cognitive task analysis describing cognitive processes underlying task performance and cognitive strategies in complex situations. This stage is conceptually divided into four quadrants including perceive, recall, plan and perform. Each quadrant is broken down into 3 subquadrants and several underlying information processing strategies termed "descriptors"[12] as shown in Figure 1. This article would like to present only stage two analysis in order to set goals for PRPP intervention in another phase of the thesis.

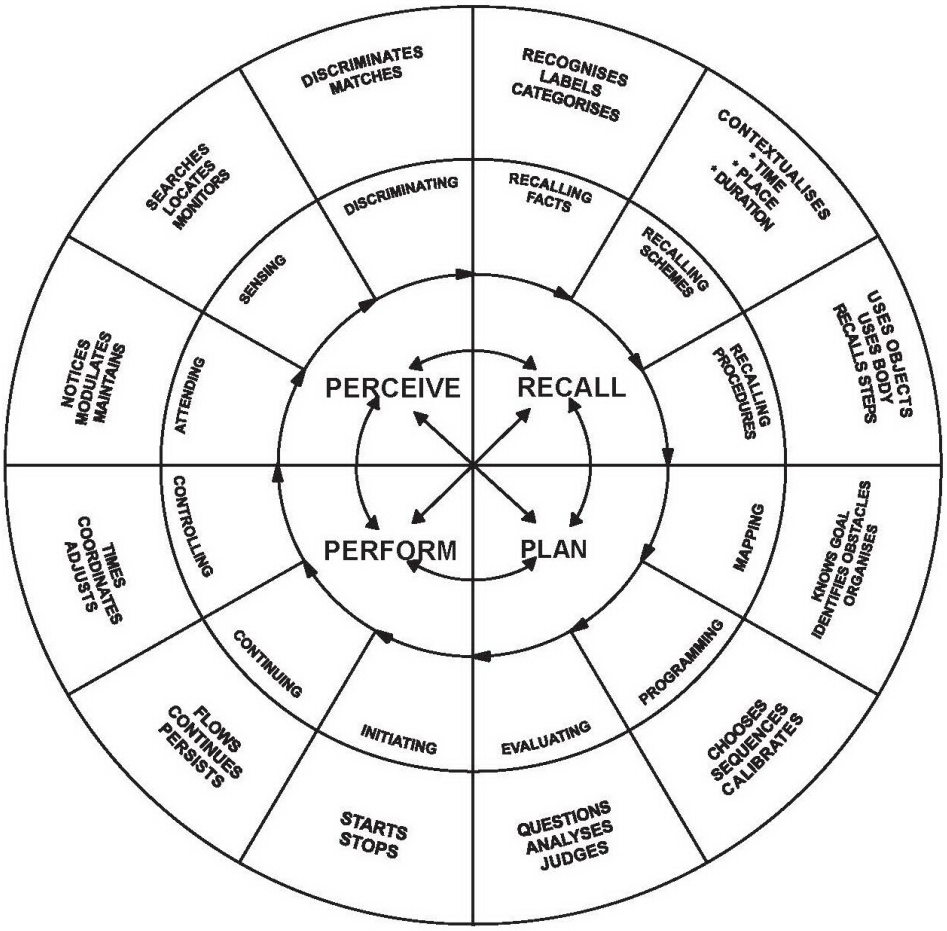

Figure 1. *PRPP system of task analysis: Conceptual model of information processing behaviors.*

Many researchers have conducted studies on the PRPP system of task analysis that has been used to assess cognitive deficits in a variety of samples including adults with traumatic brain injury,[13-15] persons with schizophrenia,[16] men with HIV-1 dementia,[17] typical children,[4,18-19] children with learning disabilities,[3,20-22] and children with autism. [23] In Thailand, PRPP system of task analysis has been translated into Thai and studied for its reliability by Munkhetvit as part of her doctoral thesis.[14] Findings of psychometric properties of the PRPP system: Thai version, demonstrated excellent test-retest reliability (ICC ranged between 0.92 and 0.96). Inter-rater reliability indicated acceptable inter-rater reliability based on total quadrant scores, with ICCs ranged between 0.65 and 0.83. Moreover, the PRPP system: Thai version has been used in Thai context in clients with stroke, person with schizophrenia, and the elderly with dementia. However, the PRPP system: Thai version has never been used in Thai children. Therefore, in this study, PRPP system: Thai version was used to explore information processing strategies application in Thai children with LD.

This work aimed to explore information processing strategy dysfunctions on different kinds of play activities in Thai children with learning disabilities. The researcher expected that information obtained would strengthen knowledge in occupational therapy regarding the use of occupation-focused assessment for measuring cognitive functions in children with learning disabilities in Thailand.

Materials and Methods

Participants

Children diagnosed with LD were recruited by purposive sampling method. All are reading disabilities and never been exposed to the intervention or received intervention less than one session per week. There were a total of 25 male and 5 female participants in the study. Age range of participants was 9-12 years (mean 10.8 years). Participants were in grade 4 to 6 in 6 inclusion

schools in the broader area of Chiang Mai Province, Thailand, which had children diagnosed with learning disabilities. Inclusion criteria of grades based on the similarity of cognitive development.[24]

Instrument

The PRPP system: Thai version[14] was used with the sample in this study.

Procedure

Proposal was submitted to the Ethics Committee of the Faculty of Associated Medical Sciences, Chiang Mai University for approval. Researcher asked for permission from the director of the Rajanagarindra Institute of Child Development, Chiang Mai, to access lists of name and school of children with LD receiving services from the institute. Directors of each school were then asked for permission to contact teachers working with special need children. Thirty children with learning disabilities were recruited according to the predetermined criteria. After parents signed informed consent document, all participants were asked to perform 3 play activities including cognitive games (jigsaw, puzzle, maze), movement activities (searching for the treasures on the map, bouncing the ball with two hand in a zigzag manner, throwing the ball into the basket), and competitive plays (domino, bingo, stacking). Criteria for specifying activities to detect information processing strategy application were based on the PRPP system of task analysis.[12] Criteria included assessment activities should be considered as important and meaningful for child's daily life, children must be familiar with the material and equipment used in the activities, or has participated in the activities before, and activities are able to be divided into task steps, and must be diverse based on the abilities and limitations of children. However, the participants might have different skills so some activity might be easy for some participants but not for the others. Therefore, in this study, each participant would be assigned for assessment activity based on his or her ability. For example, in the cognitive games, a jigsaw game was selected for one participant while the puzzle game was suitable for another. In addition to the PRPP system criteria, the assessment activities selected for data collection in this study were based on the performance areas of the Occupational Therapy Practice Framework: Domain and Process (3rd Edition)[25] in the play areas. After assessment activities were selected, activity performing of each participant was VDO recorded by researcher and research assistant who was an occupational therapist. The researcher systematically observed video footages of performance, and scored according to the PRPP System: Thai Version in the Stage Two Analysis.

The stage two analysis provided a total PRPP score comprised of quadrant, sub-quadrant scores and individual descriptor scores. The total PRPP system score and the quadrant scores, perceive, recall, plan and perform, were used for analysis in this study as they reflected the broader areas of information processing strategy application focused in this study. The total PRPP system quadrant, sub-quadrant, and individual descriptor scores were converted to total percentages.

Data analysis

Scores obtained from stage two analysis of the PRPP system: Thai version was analyzed using descriptive statistics. Mean quadrant, sub-quadrant, and individual descriptor scores were computed based on descriptive statistics to identify group means, standard deviations and percentage scores.

Results

Demographic characteristics

Table 1 Demographic characteristics of the sample group (N=30).

General data		N=30	Percent (%)
Sex			
	Male	25	83.33
	Female	5	16.67
Age	9.0-9.11	1	3.33
(Years)	10.0-10.11	12	40.00
	11.00-11.11	11	36.67
	12.00-12.11	6	20.00
Grade	4	10	33.33
	5	11	36.67
	6	9	30.00

Demographic characteristics of sample was shown in Table 1. Thirty children with LD who met the inclusion criteria were selected to participate in the study. The average age were 10.8 years old with males (83.33%) and were studying in the 5th grade (36.67%).

Information Processing Strategy Application Errors

Detail of mean total scores on each quadrant of PRPP system: Thai version of each assessment activities was presented as follow:

1) Cognitive games (jigsaw, puzzle, maze)

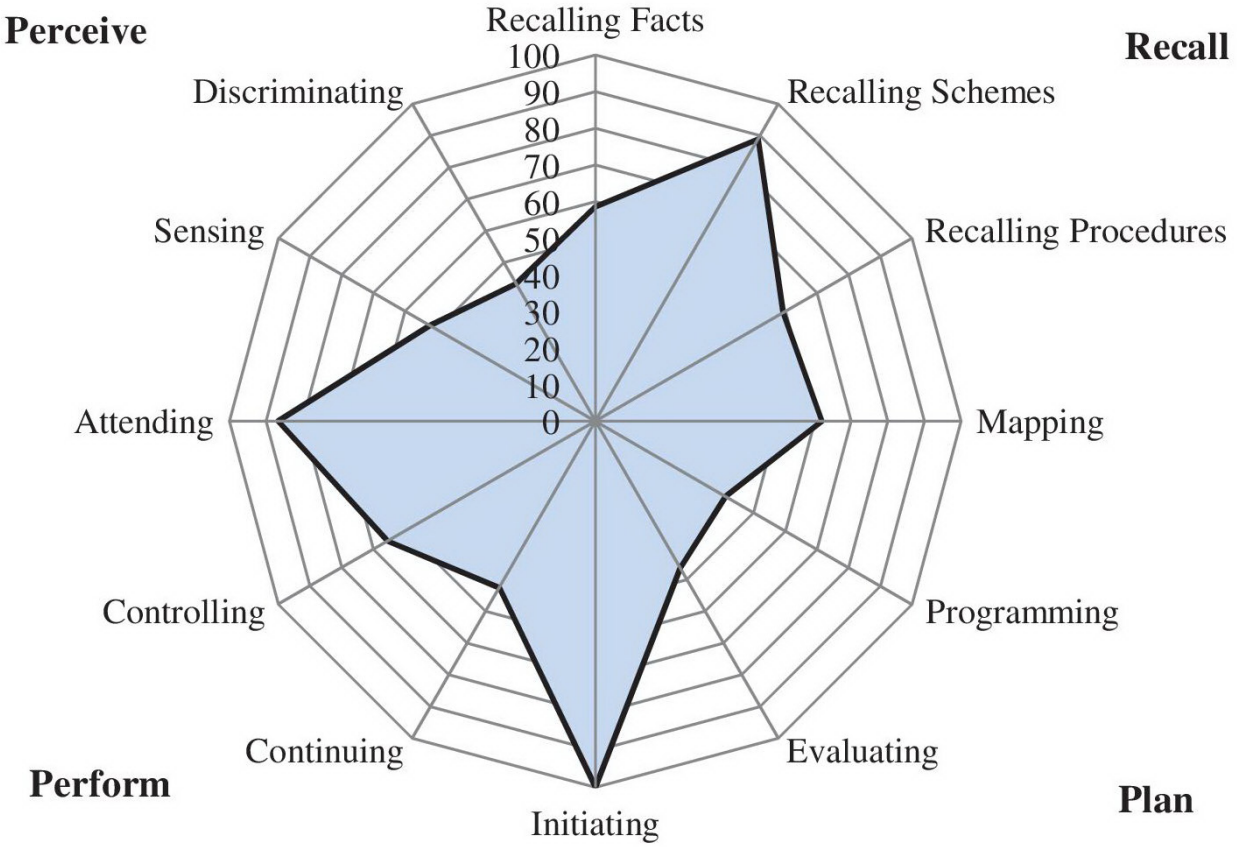

Figure 2. Information processing during cognitive games.

Figure 2 showed that plan quadrant which displayed the most difficult application was programming sub-quadrant (41.11%). Discriminating sub-quadrant was the most problem in perceive quadrant (43.33%). For the perform quadrant, continuing sub-quadrant (52.56%) presented the most difficulties. In addition, recall quadrant operations associated with recalling facts sub-quadrant (58.56%) was the most difficulty application in cognitive games for these children.

Table 2 PRPP stage two 'descriptor' percentages of cognitive game.

Data Code	Descriptor	Min.	Max.	Mean	Mean%	SD.
Perceive	ATTENDING					
	Notices	1.00	3.00	2.55	85.00	0.78
	Modulates	1.00	3.00	2.24	74.67	0.83
	Maintains	3.00	3.00	3.00	100.00	0.00
	SENSING					
	Searches	1.00	3.00	1.52	50.67	0.63
	Locates	1.00	3.00	1.52	50.67	0.63
	Monitors	1.00	3.00	1.72	57.33	0.70
	DISCRIMINATING					
	Discriminates	1.00	3.00	1.31	43.67	0.54
	Matches	1.00	3.00	1.31	43.67	0.54
RECALL	RECALLING FACTS					
	Recognises	1.00	3.00	2.45	81.67	0.91
	Labels	1.00	3.00	1.69	56.33	0.89
	Categorises	1.00	3.00	1.21	40.33	0.49
	RECALLING SCHEME					
	Contextualises to Time	3.00	3.00	3.00	100.00	0.00
	Contextualises to Place	3.00	3.00	3.00	100.00	0.00
	Contextualises to Duration	1.00	3.00	2.03	67.67	0.73
	RECALLING PROCEDURES					
	Uses Object	1.00	3.00	1.14	38.00	0.44
	Users Body	2.00	3.00	2.55	85.00	0.51
	Recalls Steps	1.00	2.00	1.69	56.33	0.47
PLAN	MAPPING					
	Knows Goal	1.00	3.00	2.93	97.67	0.37
	Identifies Obstacles	1.00	2.00	1.41	47.00	0.50
	Organises	1.00	2.00	1.24	41.33	0.44
	PROGRAMMING					
	Chooses	1.00	2.00	1.10	36.67	0.31
	Sequences	1.00	2.00	1.31	43.67	0.47
	Calibrates	1.00	2.00	1.31	43.67	0.47

Table 2 PRPP stage two 'descriptor' percentages of cognitive game. (continued)

Data Code	Descriptor	Min.	Max.	Mean	Mean%	SD.
	EVALUTING					
	Question	1.00	3.00	1.21	40.33	0.56
	Analyses	1.00	2.00	1.59	53.00	0.50
	Judges	1.00	3.00	1.41	47.00	0.63
PERFORM	INITIATING					
	Starts	3.00	3.00	3.00	100.00	0.00
	Stops	3.00	3.00	3.00	100.00	0.00
	CONTINUING					
	Flows	1.00	2.00	1.17	39.00	0.38
	Continues	1.00	3.00	1.21	40.33	0.49
	Persists	2.00	3.00	2.38	79.33	0.49
	CONTROLLING					
	Times	1.00	2.00	1.17	39.00	0.38
	Coordinates	1.00	3.00	1.76	58.67	0.58
	Adjusts	3.00	3.00	3.00	100.00	0.00

Table 2 also showed that the most difficulty of information processing strategies application for children with LD was chooses descriptor (36.67%) (programming sub-quadrant), discriminates (43.67%) and matches descriptors (43.67%) (discriminating sub-quadrant), flow (39.00%) and continues descriptors (40.33%) (continuing sub-quadrant), times descriptors (39.00%) (control sub-quadrant), and recalls steps descriptors (69.17%) (recalling sub-quadrant).

2) **Movement Activities** (searching for the treasures on the map, bouncing the ball with two hand in a zigzag manner and throwing the ball into the basket)

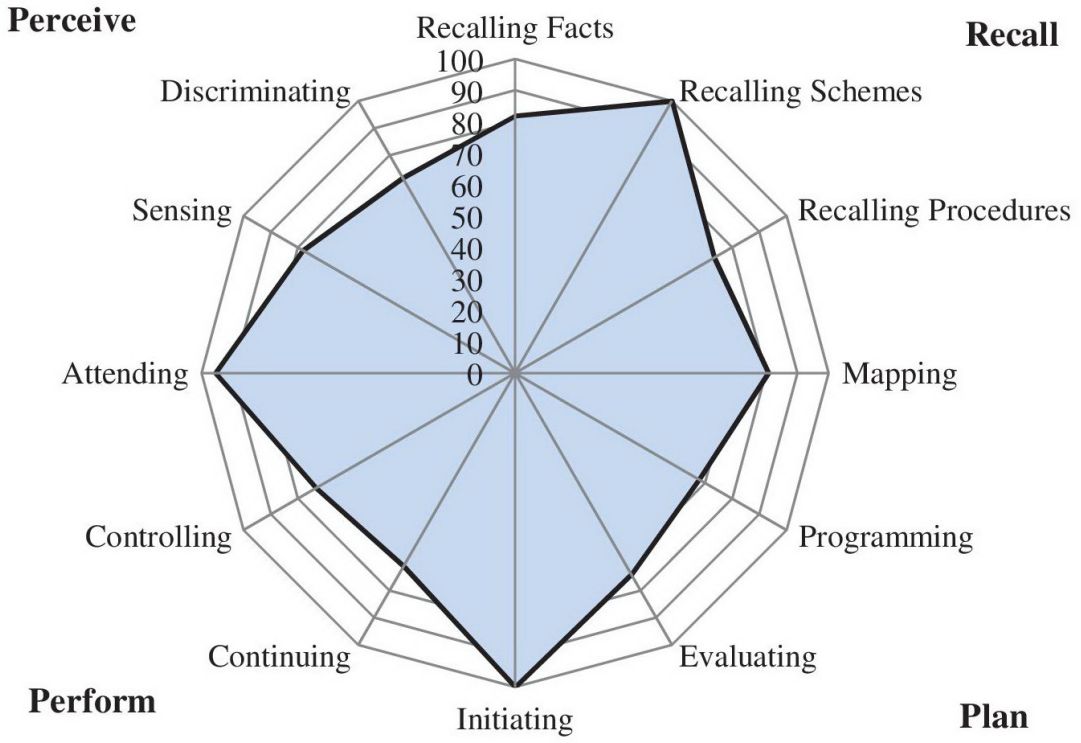

Figure 3. *Information processing during movement activities.*

From Figure 3, it can be shown that plan quadrant illustrated the most errors was programming sub-quadrant (67.78%). Continuing sub-quadrant showed the most problem in perform quadrant (71.11%). In the perceive quadrant, discriminating sub-quadrant (mean 71.67%) presented the most difficulties. Moreover, recalling procedures sub-quadrant in recall quadrant was the next problem on movement activity (73.33%).

Table 3 PRPP stage two 'descriptor' percentages of movement activities.

Data Code	Descriptor	Min.	Max.	Mean	Mean%	SD.
Perceive	ATTENDING					
	Notices	3.00	3.00	3.00	100.00	0.00
	Modulates	2.00	3.00	2.60	86.67	0.50
	Maintains	3.00	3.00	3.00	100.00	0.00
	SENSING					
	Searches	1.00	3.00	2.70	90.00	0.65
	Locates	1.00	3.00	2.30	76.67	0.65
	Monitors	1.00	3.00	2.00	66.67	0.91
	DISCRIMINATING					
	Discriminates	1.00	3.00	2.20	73.33	0.92
	Matches	1.00	3.00	2.10	70.00	0.88
RECALL	RECALLING FACTS					
	Recognises	1.00	3.00	2.48	82.67	0.83
	Labels	1.00	3.00	2.48	82.67	0.83
	Categorises	1.00	3.00	2.34	78.00	9.94
	RECALLING SCHEME PROCEDURES					
	Contextualises to Time	3.00	3.00	3.00	100.00	0.00
	Contextualises to Place	3.00	3.00	3.00	100.00	0.00
	Contextualises to Duration	3.00	3.00	3.00	100.00	0.00
	RECALLING PROCEDURES					
	Uses Object	1.00	3.00	2.41	80.33	0.87
	Users Body	1.00	3.00	2.10	70.00	0.90
	Recalls Steps	1.00	3.00	2.00	66.67	0.96
PLAN	MAPPING					
	Knows Goal	2.00	3.00	2.93	97.67	0.26
	Identifies Obstacles	1.00	3.00	2.38	79.33	0.68
	Organises	1.00	3.00	1.93	64.33	0.80
	PROGRAMMING					
	Chooses	1.00	3.00	2.17	72.33	0.80
	Sequences	1.00	3.00	1.76	58.67	0.87
	Calibrates	1.00	3.00	2.03	67.67	0.78

Table 3 PRPP stage two 'descriptor' percentages of movement activities. (continued)

Data Code	Descriptor	Min.	Max.	Mean	Mean%	SD.
	EVALUTING					
	Question	1.00	3.00	2.45	81.67	0.69
	Analyses	1.00	3.00	2.14	71.33	0.74
	Judges	1.00	3.00	2.21	73.67	0.82
PERFORM	INITIATING					
	Starts	3.00	3.00	3.00	100.00	0.00
	Stops	3.00	3.00	3.00	100.00	0.00
	CONTINUING					
	Flows	1.00	3.00	1.66	55.33	0.86
	Continues	1.00	3.00	1.66	55.33	0.86
	Persists	3.00	3.00	3.00	100.00	0.00
	CONTROLLING					
	Times	1.00	3.00	2.03	67.67	0.78
	Coordinates	1.00	3.00	2.24	74.67	0.91
	Adjusts	1.00	3.00	2.24	74.67	0.91

Table 3 presented means, standard deviations and range of scores of each 'descriptor' on the movement activity. Strategy application behaviors that were the most problems in children with LD for each of sub-quadrant mentioned above were flows (55.33%) and continues descriptors (55.33%) (continuing sub-quadrant), sequences descriptors (58.67%) (programming sub-quadrant), recalls steps descriptors (66.67%) (recalling sub-quadrant), and monitors descriptor (66.67%) (sensing sub-quadrant).

3) Competitive plays (domino, bingo, stacking)

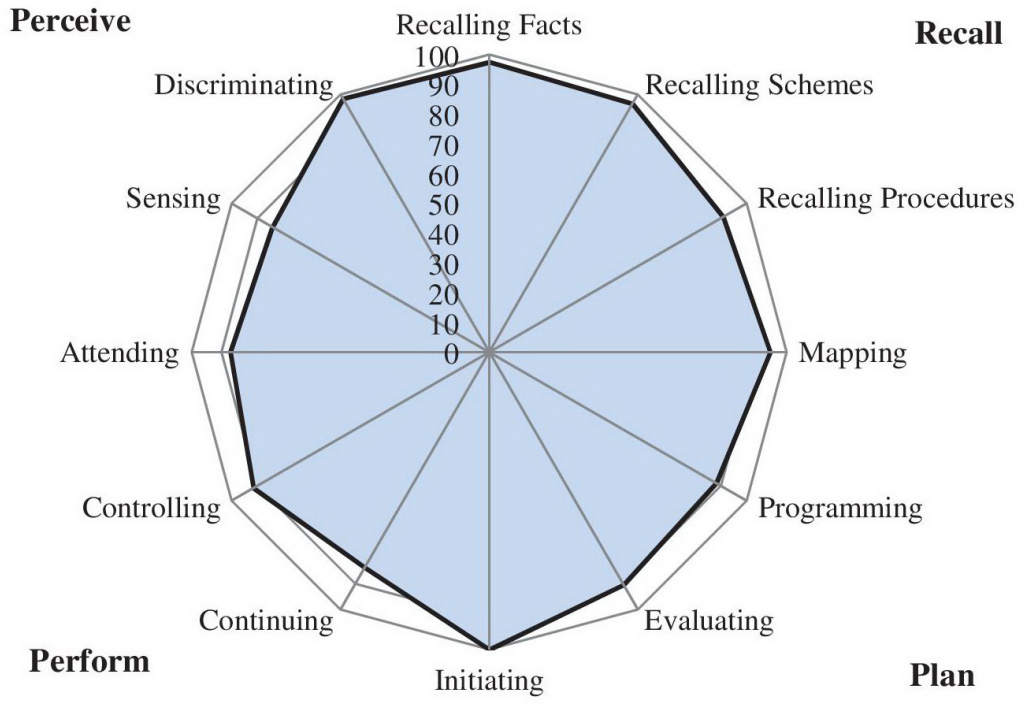

Figure 4. Information processing during competitive play.

It was illustrated in figure 4 that total scores of each quadrant were high. However, some sub-quadrant were found critical in this sample group involving sensing (84.11%) in perceive quadrant and continuing sub-quadrant (83.67%) in perform quadrant.

Table 4 PRPP stage two 'descriptor' percentages of competitive play.

Data Code	Descriptor	Min.	Max.	Mean	Mean%	SD.
Perceive	ATTENDING					
	Notices	3.00	3.00	3.00	100.00	0.00
	Modulates	2.00	3.00	2.53	84.33	0.51
	Maintains	1.00	3.00	2.30	76.67	0.92
	SENSING					
	Searches	1.00	3.00	2.63	87.67	0.72
	Locates	2.00	3.00	2.77	92.33	0.43
	Monitors	1.00	3.00	2.10	70.00	0.88
	DISCRIMINATING					
	Discriminates	2.00	3.00	2.97	99.00	0.18
	Matches	1.00	3.00	2.93	97.67	0.37
RECALL	RECALLING FACTS					
	Recognises	2.00	3.00	2.97	99.00	0.18
	Labels	2.00	3.00	2.93	97.67	0.25
	Categorises	3.00	3.00	3.00	100.00	0.00
	RECALLING SCHEME PROCEDURES					
	Contextualises to Time	2.00	3.00	2.72	90.67	0.45
	Contextualises to Place	2.00	3.00	2.97	97.67	0.25
	Contextualises to Duration	3.00	3.00	3.00	100.00	0.00
	RECALLING PROCEDURES					
	Uses Object	1.00	3.00	2.77	92.33	0.50
	Users Body	1.00	3.00	2.83	94.33	0.46
	Recalls Steps	1.00	3.00	2.57	85.67	0.57
PLAN	MAPPING					
	Knows Goal	2.00	3.00	2.93	97.67	0.25
	Identifies Obstacles	2.00	3.00	2.93	97.67	0.25
	Organises	1.00	3.00	2.63	87.67	0.56
	PROGRAMMING					
	Chooses	1.00	3.00	2.77	92.33	0.50
	Sequences	1.00	3.00	2.63	87.67	0.56
	Calibrates	1.00	3.00	2.53	84.33	0.63

Table 4 PRPP stage two 'descriptor' percentages of competitive play. (continued)

Data Code	Descriptor	Min.	Max.	Mean	Mean%	SD.
	EVALUTING					
	Question	1.00	3.00	2.67	89.00	0.55
	Analyses	1.00	3.00	2.63	87.67	0.56
	Judges	1.00	3.00	2.62	87.33	0.56
PERFORM	INITIATING					
	Starts	3.00	3.00	3.00	100.00	0.00
	Stops	3.00	3.00	3.00	100.00	0.00
	CONTINUING					
	Flows	1.00	3.00	2.31	77.00	0.66
	Continues	1.00	3.00	2.31	77.00	0.66
	Persists	1.00	3.00	2.86	95.33	0.52
	CONTROLLING					
	Times	1.00	3.00	2.41	80.33	0.57
	Coordinates	1.00	3.00	2.86	95.33	0.52
	Adjusts	1.00	3.00	2.93	97.67	0.37

Table 4 presented means, standard deviations and range of scores of each 'descriptor' in competitive play. Strategy application behaviors posed the most difficult application of participants for each sub-quadrant mentioned above were monitor descriptors (70.00%) (sensing sub-quadrant), flows (77.00%) and continues (77.00%) descriptors (continuing sub-quadrant).

In conclusion, the study detected a variation of problems to different extent in 3 assessment activities on each quadrant of PRPP system: Thai version. The cognitive games were the most novel and complex activities because they required extensive planning and decision making. Total scores of this activity in all quadrants in PRPP system were relatively lower than that of other, especially in plan and perceive quadrant. Total scores in movement activities, as the least complex but high novel, was reported to be lowest in plan and perform quadrant. Total scores in the competitive plays were relatively higher than other activities because children were familiar with these activities. However, score of the competitive plays was reported to be lowest in plan and perceive quadrant.

Discussion

Types of strategy application deficits are identified by stage two of the PRPP system of task analysis. This stage of the PRPP system is divided into 4 quadrants: perceive recall, plan, and perform. Each quadrant is divided into more specific 'sub-quadrants' of cognitive processing that represent information processing operations. "descriptors" representing a behavior associated with a specific processing operation defined by each sub-quadrant that relates to processing focus of that particular quadrant. Application of information processing strategy is defined as the cognitive and metacognitive functions required for everyday life activities. This study revealed that all children had difficulty in applying the information processing strategies needed to complete tasks safely, effectively, and efficiently in real-world contexts. Severity of the difficulty found in this study depended on patterns, novelty and complexity of the activities. This finding was consistent with previous studies in the field of developmental neuropsychology over the past two decades in that children will use executive function skill to solve novel and complex tasks.[26] Welsh

and Pennington noted that "behaviors such as planning, flexibility, and self-monitoring are evident throughout the life span, albeit the manifestations change with cognitive maturation".[27]

Plan quadrant was the most problematic quadrant for participants on all assessment activities, especially cognitive games which were novelty and complexity task. Plan is behavioral strategies associated with making plans, decisions and judgments about nature and quality of performance. In order to complete a task with many steps, children must plan their actions before performing. They must consider alternatives, organizes themselves and required materials, remember the steps sequence of their plan. Moreover, during performing the task, they must monitor their plan and make necessary organizes to ensure success.[28] This finding was corresponded to the previous studies of using the PRPP system of task analysis to explore the information processing strategies application errors in children LD.[3,20] The finding of these studies showed that planning was the most difficult for children in sample group. Pulis and Chapparo used eight school tasks which suitable for aged 6-8 years including coloring, cutting and pasting, drawing, writing a story, paper folding, tying shoelaces, catching a ball and skipping.[3] When scores for all eight school tasks were combined, a direct ordering of quadrants was found with plan emerging as the most problematic quadrant. Evaluating and programming (plan quadrant) and recalling procedure (recall quadrant) were the most difficulty sub-quadrant. Although, plan quadrant was the most problematic on all assessment activities in this study, another quadrant was also challenge for participants. The orders of a challenging quadrant were different based on pattern of play activities. Therefore, discussions based on the assessment activities are as follows:

1. **Cognitive games** (jigsaw, puzzle, and maze)

   Like academic tasks, plan, perceive, perform and recall were problematic in the cognitive games. The significant descriptors in plan quadrant appeared to be the problems including *chooses* (programming sub-quadrant), *questions* (evaluating sub-quadrant) and *organizes* (mapping sub-quadrant). Plan quadrant encompassed the metacognitive components of information processing which facilitates the formulation of a plan to achieve a task objective and a specific sequence of steps. In a task with novelty and complexity, it specifically requires ability to organize.[29-30] Some researchers found that children with LD have been struggled with ability to organize materials and classroom activities.[31] Activities in cognitive games (jigsaw, puzzle, maze) in this study were quite novel and complex for participants. However, typical children would be able to participate in these activities independently. To complete these activities, children must apply metacognitive strategies which are important for the maintenance and generalization of skills and application of learned skill. The strategies include planning and problem solving, making inference and decision making, modulating and switching attention between task components, monitoring information, and readjusting responses.[32-33] Children who fail to conduct some of these strategies appear to possess learning disabilities.[34] For example, in jigsaw game, participants needed to choose suitable pieces of jigsaw to match with other pieces. They would be suspected if any pieces had been put in the wrong place. They would learn how to organize the jigsaw component.

   Perceive was another problematic quadrant for cognitive games, especially for *discriminates and matches* descriptors (discriminating sub-quadrant) and *searches* and *locates* descriptors (sensing sub-quadrant). Errors found in these descriptors were caused by visual perception problem which was a prevailing obstacle for children with LD, especially dyslexia.[35] There are different types of visual perception. Each has differently impacted on a complex task which was analyzed as follows; children with visual attention disorder are more likely to fail to observe details needed for learning and participating in activities or receive unnecessary information distracted them from the focus. Children with visual closure disorder are unable to identify the incomplete parts of forms or objects.

Therefore, they could not mentally complete visual image or relate it with the previous store information.[36] According to the study, children could not imagine the complete picture of a jigsaw and could not complete the game. Children with visual form constancy, visual discrimination, and visual figure ground discrimination disorders were struggled with searching, locating, matching and discrimination of objects. Children with spatial perception disorders were struggled with orientation and position of objects and orientation between themselves to surrounding environment. These disorders affect depth perception, understanding of a map and reversed image perception.

The most problematic descriptors found in the perform quadrant included *flows* and *continues* descriptors as in continuing sub-quadrant and *times* descriptors as in control sub-quadrant. Study reported the children frequently failed to participate in activities demonstrated that they could not follow the instruction, took too long to finish their task and especially needed guidance to achieve the task. This is because these children possessed metacognition impairment. Many studies reported that children with metacognition impairment had a relatively slower speed of cognitive processing than typical children and took longer time to finish the assignment.[37] Processing speed significantly correlates with participatory and academic skills in school, ranging from a simple to complex activity. It is not surprising that children with LD would fail to participate in school activities such as academic tasks, keyboard typing, game activities, and sports.

Though recall was reported to be the least problematic quadrant in cognitive game, *contextualizes to durations* descriptor (recalling schemes sub-quadrant), *use object* and *recall steps* descriptors (recalling procedures sub-quadrant), and *categorizes* descriptors (recalling facts sub-quadrant) were reported to be critical for samples. Activities used to assess information processing strategies had to be complex enough to reveal problems from information processing in children with LD. Problems found in recall quadrant were in the same direction: students were struggled to follow instructions demonstrated before and could not appropriately and correctly choose and group objects. For example, children could not differentiate pieces of jigsaw and group them by color or edging. Moreover, they took long period of time to finish the task exceeding the appointed time. Limitation of recall can be used to measure the efficiency of working memory.[38] Children with poor working memory show incomplete recall and struggle in activities which require storage and manipulating information.[39] Working memory is significant for activities that require cognitive processing. To complete the cognitive task, it is important to hold information in process until it is integrated into a full concept.[38] Children with working memory impairment failed to recall the multi-step instructions or rules and to complete a task involving calling up necessary information.[40]

2. **Movement activities** (searching for the treasure on the map, bouncing the ball with two hand in a zigzag manner, and throwing the ball into the basket)

Plan and perform were reported to be the most important quadrant in movement activity in which *sequences* descriptors in programming sub-quadrant (plan), *flows* and *continuous* descriptors in continuing sub-quadrant, *times, coordinates*, and *adjusts* descriptors in controls sub-quadrant (perform) were reported to be the most problematic errors. These findings were consistent with Pulis and Chapparo's study in that the most of assessment activities required a coordinating movement were used to explore information processing strategies application errors in children with LD such as catching a ball, cutting and pasting, tying a shoelace.[3] The result revealed that plan and perform were the most problematic quadrant for samples.

Assessment results showed that movement activities substantially required motor coordination ability. However, many studies reported that impairment of the development of motor coordination co-existed with specific learning disabilities.[41-42]

Factors affecting motor coordination ability in LD children were caused by slow information processing. Brown reported that slow information processing impacted coordination ability and integration between multiple skills and information sources.[43] Other significantly further contributed to motor coordination was impaired information processing.[44]

Generally, movement involves the cortical or brain-directed process of motor planning (praxis). The praxis process consists of (1) ideation: ability to mentally set up a motor objective and design of ways to achieve it; (2) motor planning: ability to intentionally plan and sequence the motor actions required to achieve the objective: (3) motor coordination: ability to accomplish movements with precision; and (4) feedback: ability to recognize the achievement of motor objective and respond to consequences.[45] This process of movement shows that plan and sequence process in motor action are crucial components of motor planning process, which will continually enhance motor coordination process. Findings from this study conformed to the above information that there were errors not only in perform quadrant but also in plan quadrant, especially for the sequence descriptor which was reported to be the most important error in movement activity. Furthermore, poor motor coordination ability is a result of poor perception. Many researchers shared that movement process was a deliberation of perception, decision and effecter.[46-47] Wilson and McKenzic set a hypothesis that there would be a poor motor coordination if movement process was interrupted in any stage.[48] Kurtz claimed that perceptual processing regarding movement consisted of visual kinesthetic, and cross-modal perception.[36] This study was consistent with Kurtz's study that visual perception, especially visual-spatial perception caused errors in *discriminations* and *matches descriptors* (discrimination sub-quadrant in perceive quadrant). Another factor affecting movement was slow processing speed ability which took children with LD too long to finish assignments and caused errors in following *times* descriptor.

Recall was reported to be the least problematic quadrant in movement activity. Recall step was the only problematic descriptor since it required working memory to complete assignments. If recall step is impaired, one would be struggled with remembering instructions, organizing time toward the deadline, especially in activities with multiple steps and complex sequences which was obvious in assessment activities such as bouncing a ball with switching hands and a treasure hunting game that followed a map.[49-50] Children with LD in this study were struggled to be aware of depth perception and location or direction in a map.

3. **Competitive plays** (domino, bingo, and stacking)

Although total scores of PRPP system in each quadrant on competitive plays were higher than another 3 assessment activities, some descriptors were critical in this samples including *monitors* descriptor in sensing sub-quadrant followed by *flows* and *continues* descriptors (continuing sub-quadrant), and *times* descriptor (control sub-quadrant). All activities necessary to children including ADL, i.e. playing in any way such as card games, music, sport, singing, and dancing, have to utilize monitoring their actions in order to determine the next step, and also evaluate what would happen after their decision. During group activities, children often forgot their sequence and unaware for making a mistake. Factor dealing with these problems is slow processing speed which makes children react very slowly and causes errors in the *flows* and *continues* and *times* descriptors. However all errors had less problems when compared to other activities.This may be caused by stimulation and feedback from other children in the group. Children also copied friend's behavior which made them less able to use an information processing strategy, especially recalling and planning. All are consistent to McDonald who used peers to deliver self-monitoring strategy in children with disabilities which here can help support and motivate their learning.[51]

Conclusion

Analysis of the performance demonstrated that participants had difficulties in all stages of information processing in all kinds of play activities. Plan quadrant produced the most problems while recall quadrant was reported to be the least problematic quadrant.

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