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Preceding Research on Comparative Analysis of the Validity of Game based Cognitive Training Program for Children with Intellectual Disabilities

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지적장애 아동을 위한 게임형 인지훈련 프로그램의 타당도 선행 연구 비교 분석

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Abstract Recently, many cognitive training programs based on digital contents have been presented, but few digital contents have been produced for children with intellectual disabilities among children with developmental disabilities. Digital contents based training programs are needed to apply remotely untact training programs rather than face-to-face apprenticeship classes for improving the cognition of children with intellectual disabilities. This study was attempted to present the new cognitive training program by analyzing concurrent validity, which was analyzed by the correlation between items by comparing with subtests of K-WISC-IV and items of game based Neuro-World cognitive training program. It was found that there are some validity by analyzing correlation between the subtests of K-WISC-IV and the items of Neuro-World program, which means that it has concurrent validity of some items of Neuro-World program. In terms of reliability, the Cronbach alpha value was 0.794, indicating that game performance of children with intellectual disabilities and the degree of level increase in each game were somewhat reliable. This is considered to be a significant result in future studies for clinical trials of cognitive training tools.

Key Words : Developmental disabilities, Cognitive training, Digital contents, K-WISC-Ⅳ, Concurrent validity

요 약 최근 많은 디지털 콘텐츠가 제시되고 있지만, 발달장애 아동 중 지적장애 아동을 대상으로 한 디지털 콘텐츠는 거의 제작되지 않았다. 지적장애 아동의 인지 개선을 위한 훈련프로그램을 기존의 대면 도제식 수업이 아닌 비대면 원격으로 수업을 진행하기 위해서는 디지털 콘텐츠 기반의 훈련 프로그램이 필요하다. 본 연구는 게임 기반으로 제작된 뉴로월드의 항목과 K-WISC-Ⅳ의 소항목과 비교하여 항목 간 상관관계로 공인 타당도를 분석함으로써 새로운 인지훈련 프로그램을 제시하고자 하였다. 검사항목과 훈련 항목 간의 상관관계에 있어 일부 타당성이 있는 것으로 나타났고, 이는 일부분의 훈련 항목이 공인 타당성을 지니고 있다는 것을 의미한다. 신뢰도 측면에서는 Cronbach 알파값이 0.794로 지적장애 아동들의 게임 수행력과 각 게임마다의 레벨 상승 정도가 어느 정도 신뢰성이 있는 것으로 나타났다. 이는 인지훈련 도구의 임상실험을 위한 향후 연구에 있어서 유의미한 결과로 사료된다.

주제어 : 발달장애, 인지훈련, 디지털 콘텐츠, K-WISC-IV, 공인 타당도

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1. Introduction

As the number of patients related to brain diseases is increasing in modern society, the importance of early diagnosis and treatment of brain diseases is gradually increasing [1]. In particular, since developmental disability that causes damage to social, academic, or professional functions are mainly manifested in school age, which is a developmental stage, it is important to diagnose early and conduct rehabilitation training at an appropriate time [2,3]. According to data released in 2021, the number of people with developmental disabilities nationwide has steadily increased every year since 2013, accounting for about 9.44% of the registered disabled in present [4]. There are various types of developmental disabilities such as intellectual disabilities, autism, and development retardation, of which 50.8% are intellectual disabilities [4]. Intellectual disability refers to a state in which overall cognitive abilities such as memory, attention, processing ability, problem-solving, and reasoning are defective due to limited learning ability and failure to function normally in the input, processing, and calculation steps which are learning information processing [5]. The level of cognitive ability can be identified through the intelligence quotient and the intelligence quotient is classified into very superior (above 130), superior (120-129), high average (110-119), average (90-109), low average (80-89), borderline (70-79), and extremely low (below 69) [6].

A representative intelligence tests that can identify the intelligence quotient are WISC (Wechsler Intelligence Scale for Children), MMSE (Mini-Mental State Exam), K-ABC (Kaufman assessment battery for children) and Stanford-Binet [7].

Children with intellectual disabilities have difficulty in maintaining interpersonal relationship because they cannot properly express their opinions due to a defect of cognitive ability [8]. In other words, the defect of cognitive ability negatively affects not only cognitive ability but also the overall daily life areas of life such as communication, social participation activities, and independent life in various environments [9]. Therefore, it is necessary to improve their cognitive ability by conducting customized cognitive training programs for normal daily life of children with intellectual disabilities in the future [10]. Existing traditional training programs to improve the cognitive ability of children with developmental disabilities have been conducted through two-dimensional training tools using props such as paper, pencils, puzzles, and cards [11]. However, since these methods continuously use the same props, it is difficult for children with intellectual disabilities to maintain attention, so there is a limitation to continuous training application [12].

In order to overcome this limitation, training programs using digital media are being developed [13]. Representative cognitive training programs using digital media are Endeavor Rx (Akili Interactive, USA) and RehaCom (Hasomed GmbH, Germany) [14,15]. These programs aim to improve cognitive ability of people with cognitive impairment by motivating to participate in cognitive rehabilitation programs for enabling independent daily life [16]. Motivation is a very important factor because it directly affects the effectiveness index of training [17]. Therefore, in this study, a game-based cognitive training program was developed to attract interest and motivate children with intellectual disabilities.

The developed Neuro-World cognitive training program consists of various characters

and can be automatically set to an appropriate level suitable for program users based on the data obtained through the first game results, so it has the advantage of intensively training the lacking parts. The cognitive training areas of the Neuro-World program consist of memory, attention, perception, and execution function, and the program was developed to train the ability to improve brain function and solve problems that occur in daily life by solving tasks in each area. In order to use a new program in clinical trials, verification of validity is an important process, so verification for this is necessary [18].

Therefore, this study aims to confirm the concurrent validity by analyzing the correlation between each score by comparing the score of sub-tests of K-WISC, which is currently used as intelligence test tool, with the score of the items of the Neuro-World program. By verifying the similarity between items of the Neuro-World program and subtests of the K-WISC-IV, it aims to verify whether the Neuro-World program can be used not only as a training tool but also as an test tool.

2. Materials and Methods

This study was conducted on 30 children aged 6 to 13 with congenital intellectual disabilities who participated in six child development clinics in a specific area through IRB. The criteria for selecting children were as follows : IQ 〈 70 as per an intelligence test (K-WISC-IV) conducted, intellectual disabilities, as diagnosed by a specialist, sufficient hearing to recognize sound effects from software, no prior experience of participating in other AI-based cognitive training programs, written consent from a legal representative.

A total of 30 children with intellectual disabilities participated in this study, male and female with 23 (77%) and 7 (23%), respectively. The average age of the male group was 8.82±1.55 years old, and the female group was 8.29±1.98 years old. The average IQ of the male group was 62.74±2.35 and that of the female group was 64±4.07.

The Neuro-World program, produced in a game-type using digital media, is a training program to improve four cognitive areas: memory, attention, perception, and execution function. It consists of six sub-items for four cognitive areas. And it also consists of various characters and game methods that can attract interest in children with intellectual disabilities. The initial login page of the Neuro-World cognitive training program is shown in Fig. 1. When logging in, the personal accounts were encoded numerically to comply with privacy standards. All game levels consist of 1 to 20, and the game progress screen according to the level of each area is shown in Fig. 2.

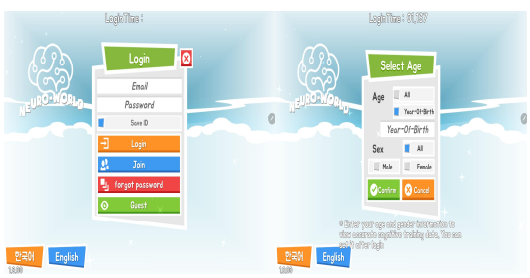

Fig. 1. Initial login page of the Neuro-World cognitive training program

(a) Perception Memory (Level 10)

(b) Object Memory (Level 20)

(c) Selective Attention (Level 10)

(d) Vigilance Attention (Level 20)

(e) Visual Perception (Level 20)

(f) Plan (Level 20)

Fig. 2. The training screen for each cognitive area of the Neuro-World cognitive training program

In this study, K-WISC-IV was used as a diagnostic tool to identify the level of cognitive ability of children with intellectual disabilities who participated in the experiment. K-WISC-IV consists of 15 subtests for four cognitive areas: verbal comprehension, perceptual reasoning, working memory, and processing speed, of which 10 are core subtests and the remaining 5 are supplemental subtests [19,20]. This is shown in Table 1. K-WISC-Ⅳ is an intelligence test in which the full scale intelligence quotient is calculated by summing the scores of subtests [21]. The recording paper and analysis page of this test are shown in Fig. 3. In this study, the correlation between 10 core subtests of K-WISC-Ⅳ and 6 items of the Neuro-World program was analyzed using SPSS Statistics 23 software.

Table 1. Indexes and subtests of K-WISC-Ⅳ

Indexes	Subtests		
Verbal Comprehension Index (VCI)	Similarities	Vocabulary	Comprehension
Perceptual Reasoning Index (PRI)	Block Design	Picture Concepts	Marix Reasoning
Working Memory Index (WMI)	Digit Span	Letter-Number Sequencing	
Processing Speed Index (PSI)	Coding	Symbol Search	

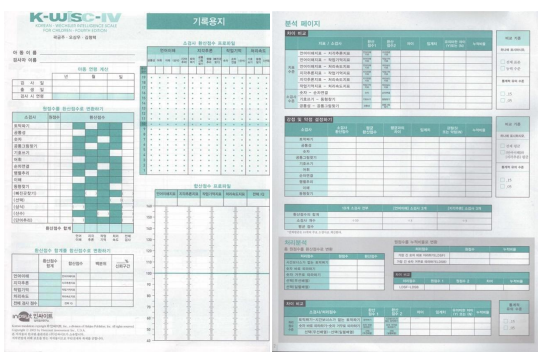

Fig. 3. The tally sheet and analysis page of K-WISC-Ⅳ

In this study, K-WISC-IV was conducted twice three months apart for 30 children with intellectual disabilities and the Neuro-World program was conducted in a total of 24 sessions, twice a week and eight times a month from August 2020. In addition, it was conducted under the supervision of a professional cognitive rehabilitation specialist because it was difficult for children with intellectual disabilities to conduct training themselves. Therefore, the correlation between each item was analyzed based on the result values obtained through the test and training, and the association between the items was reviewed.

3. Results

The results of the concurrent validity analyzed correlation between items of the Neuro-World cognitive training program and subtests of the K-WSC-Ⅳ through Pearson correlation analysis were shown in Table 2.

Through the test results of children with intellectual disabilities, plan corresponding to execution function among items of the Neuro-World cognitive training program did not show a significant correlation with the subtests of K-WISC-IV. Visual perception memory, among the memory items of the Neuro-World cognitive training program, showed a normal positive correlation (rs=.383) with digit span among the working memory index of K-WISC-IV. Object memory, among the memory items of the Neuro-World cognitive training program, showed a normal positive correlation (rs=.387, p<.05) with picture concepts among the perceptual reasoning index of K-WISC-Ⅳ and showed relatively strong negative correlation (rs=-.480, p<.01) with coding among the processing speed index of K-WISC-Ⅳ. Selective attention, among the attention items of the Neuro-World cognitive training program, showed a normal positive correlation (rs=.378, p<.05) with picture concepts among the perceptual reasoning index of K-WISC-Ⅳ and showed relatively strong positive correlation (rs=.499, p<.01) with symbol search among the processing speed index of K-WISC-Ⅳ. Vigilance attention, among the attention items of the Neuro-World cognitive training program, showed a normal positive correlation (rs=.377, p<.05) with picture concepts among the perceptual reasoning index of K-WISC-Ⅳ. Visual Perception, among the perception items of the Neuro-World cognitive training program, showed relatively strong positive correlation (rs=.563, p<.01) with digit span among the working memory index of K-WISC-Ⅳ. Therefore, significant results were found in the correlation between items in each area, excluding execution function item of the Neuro-World program and verbal comprehension index of K-WISC-Ⅳ. This is shown in Fig. 4.

The reliability was calculated through the average of the results of the six items of the Neuro-World cognitive training program for 30 children with intellectual disabilities. As a result, the Cronbach alpha value was 0.794, indicating that game performance of children with intellectual disabilities and the degree of level increase in each game were somewhat reliable.

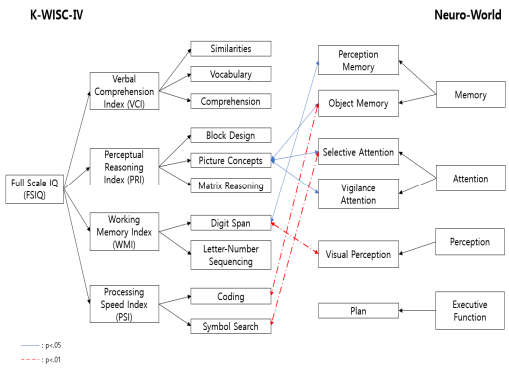

Fig. 4. The diagram of correlation with indexes of K-WISC-Ⅳ and the Neuro-World program

Table 2. The correlation with subtests of K-WISC-Ⅳ and items of the Neuro-World program

K-WISC-Ⅳ		Neuro-World program					
		Memory		Attention		Perception	Executive Function
		Perception	Object	Selective	Vigilance	Visual	Plan
Verbal Comprehension Index (VCI)	Similarities	-.020	-.193	-.058	.184	.259	.031
	Vocabulary	-.147	-.023	.065	.139	-.198	-.150
	Comprehension	.136	.002	.121	-.069	.266	-.077
Perceptual Reasoning Index (PRI)	Block Design	-.155	.284	.149	.129	.043	.183
	Picture Concepts	.348	.387*	.378*	.377*	.140	.282
	Matrix Reasoning	-.270	.076	.034	-.017	-.285	.147
Working Memory Index (WMI)	Digit Span	.383*	.129	.224	-.020	.563**	.178
	Letter-Number Sequencing	.168	.145	-.059	.106	0.000	.033
Processing Speed Index (PSI)	Coding	.097	-.480**	-.146	-.118	-.034	-.151
	Symbol Search	.153	-.091	.499**	-.017	-.147	-.002

*p<.05, **p<.01

4. Discussion

In this study, effectiveness of the game-based Neuro-World cognitive training program for children with intellectual disabilities have been verified in advance and the similarity was reviewed by analyzing correlation with the subtests of K-WISC-IV, a standard intelligence test, and the items of the Neuro-World program. Precedent research was conducted on children with intellectual disabilities, and it was intended to overcome the limitations of existing training tools through digital contents such as ease of access to training through level control and motivation to participate in training using various characters. There was a need for contents that could induce voluntary behavior of children with intellectual disabilities, which is the requirement of rehabilitation therapists at the children with developmental disabilities center. The improvement effect of cognitive ability through the Neuro-World cognitive training program was verified by conducting K-WISC-IV pre/post test, which is most commonly used as a cognitive test tool. In addition, if the training program can be used for the test tool, it will be a very effective program for children with cognitive impairments such as attention deficit.

Therefore, in this study, the interrelationship between training contents and test contents was analyzed in consideration of these points. As shown in the analysis results, the overall association between the subtests of K-WISC-IV, a test tool for children with intellectual disabilities, and the items of the Neuro-World program, a training tool, was insufficient. However, picture conception and digit span, among subtests of K-WISC-Ⅳ, showed normal correlation with perception memory, object memory, selective attention, vigilance attention among the items of the Neuro-World program. In addition, it was confirmed that there was a relatively strong correlation between digit span, coding, symbol search among the subtests of the K-WISC-IV and object memory, selective attention, visual perception among items of the Neuro-World program. Thus, it was possible to derive the results that training to improve memory and concentration can affect test items such as perceptual reasoning, working memory, and processing speed through the results of analysis. In this study, it was proved that training items that improve memory, attention, and perception ability are correlated with some subtests of K-WISC-IV, a test tool. Therefore, the possibility that the Neuro-World program can be used not only as a training tool but also as an

test tool was suggested.

In the preceding study of digital contents conducted for this study, the accuracy of game-based digital contents was compared and reviewed, and the significance of items of the Neuro-World program was proved by comparing with subtests of K-WISC-IV[16]. Therefore it can be seen that it is consistent with the results of this study through the significance of the correlation between items.

This study was attempted to obtain the validity and reliability of the Neuro-World program through correlation between the subtests of K-WISC and the items of the Neuro-World program, but several limitations on validity and reliability appeared. While K-WISC-IV is used as an test tool, the Neuro-World program is used as a training tool, so there was no significant correlation between the overall score and the validity & reliability analysis between specific items. In addition, it is difficult to compare K-WISC-Ⅳ and the Neuro-World program because there are different aspects between the subtests of K-WISC-IV and the items of the Neuro-World program. It can be known that there are some limitations in comparing training tools and test tools.

5. Conclusion

In this study, analyzing the validity between the subtests of K-WISC-IV, a test tool, and the items of Neuro-World developed as game based training tools was intended to verify and tried to lay the foundation for clinical use. As a result of analyzing the concurrent validity for 30 children with intellectual disabilities, it was found that there was a correlation between perceptual reasoning, working memory, processing speed among the subtests of K-WISC-Ⅳ and memory, attention, perception among the items of the Neuro-World program. In addition, there was a degree of reliability of the Neuro-World program.

Since K-WISC-IV is a test tool and the Neuro-World program is a training tool, there were some limitations in comparing the two tools, which have some parts of different items. However, it is considered to be meaningful in that it presented the possibility of being used as a basis for applying the Neuro-World program to clinical trials as a test tool and training program in the future through comparative analysis between the items of the two tools.

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