applied sciences

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Effect of Game-Based Cognitive Training Programs on Cognitive Learning of Children with Intellectual Disabilities

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Abstract: Early detection and repeated learning training of children with intellectual disabilities are important factors that are directly related to the quality of future life of such children. However, implementation of such programs is challenging, as the subjects are still children. Therefore, motivation and interest are important for children with intellectual disabilities to carry out continuous training. In this study, *Neuro-World*, a game-based cognitive training program, was proposed for motivation and interest induction, and its effectiveness was compared with that of a conventional cognitive training program through analysis after both programs were implemented by professional therapists. The pre-test and post-test results of the game-based cognitive training program were statistically significant and showed superiority in the comparison with the conventional program. Therefore, the game-based cognitive training program developed in this study through digital media is expected to be effective in improving cognitive learning ability.

Keywords: game-based learning program; intellectual disability; cognitive learning; digital media

Citation: Kim, S.-C.; Lee, H.-s. Effect of Game-Based Cognitive Training Programs on Cognitive Learning of Children with Intellectual Disabilities. *Appl. Sci.* **2021**, *11*, 8582. https://doi.org/10.3390/app11188582

Academic Editor: Alessandro Di Nuovo

Received: 16 July 2021
Accepted: 13 September 2021
Published: 15 September 2021

1. Introduction

Developmental disabilities are a set of disabilities that begin in the developmental stage and typically manifest during the school years, causing personal, social, academic, or professional impairment [1]. Children with intellectual disabilities do not possess sufficient attention, memory, cognition, language, or problem-solving ability, which are necessary functions for social interaction with surrounding objects [2]. Children with intellectual disabilities find it difficult to shift their attention from one task to another. Moreover, they not only have reduced stimulus discrimination ability due to the short focusing time but also have a less spontaneous attention concentration [3,4]. In particular, children with intellectual disabilities, who belong to subcategories of developmental disabilities, have defects in intellectual functions such as reasoning, problem-solving, planning, abstract thinking, judgment, academic learning, and experience learning; their daily activity functions, such as communication, social participation, and independent living in various environments, are also limited [5]. These intellectual deficiencies affect learning capabilities, leading to inadequacies in necessary functions in the input, processing, and output stages of the learning information process. This results in a strong need for individualized programs or independent training services to train and treat such disorders [6].

Cognitive ability refers to the overall ability to reasonably think and act, and effectively deal with one's own environment [7]. Deficiencies in cognitive ability affect the concentration, memory, and learning capacities [8]. The concept of intelligence—the ability to adapt judgement, actual sense, and proactive personality to the environment and rightly judge, understand, and reason—is used as the main indicator of such cognitive abilities [9]. Subcategories used as evaluation indicators of intelligence include verbal understanding, perceptual reasoning, working memory, and processing speed. The intelligence quotient

(IQ) is a sum of the values of the aforementioned indicators [10]. For children, abilities such as memory, concentration, mental control, reasoning, visual-perceptual stimulation reasoning, spatial processing, focal attention, visual discrimination, and visual-motion coordination can be quantified by measuring their IQ [11,12]. Therefore, it is vital for children with intellectual disabilities to identify and mediate their lack of cognitive abilities to ensure that they can adapt to society and have a better daily life [13].

Continuous and repetitive learning training must precede, so that children with intellectual disabilities can perform appropriate actions in various situations to live their daily lives without any inconvenience [14]. Learning training programs can be categorized into conventional cognitive training programs and cognitive training programs conducted via digital media [15]. Conventional cognitive training programs are two-dimensional training programs that utilize planar activities using paper and pencils, such as memorizing picture card positions, memorizing face cards, puzzle making, counting activities, finding the same picture activities, and sequence card activities [16]. In other words, conventional cognitive training programs utilize props such as cards, puzzles, and pictures to enhance the cognitive ability [17]. It has been reported that these programs are effective indeed, but have time and space constraints, and children with intellectual disabilities have limited concentration and quickly reducing interest in cognitive training due to repeated training and repeated intervention by the professional therapists [18]. Therefore, conventional cognitive training programs have limitations in terms of the repeated implementation of training to enhance the learning effectiveness because they pose difficulties in maintaining the motivation of children with intellectual disabilities [19].

To overcome these limitations, the implementation and study of cognitive training utilizing digital media such as computers, smartphones, and tablet PCs have recently been actively conducted [20]. These programs have no time and space constraints compared to conventional cognitive training programs and can be utilized in various activities because of their high social accessibility owing to the simplicity of their operation and portability of devices [21,22]. In addition, non-face-to-face intervention and learning has recently drawn attention due to COVID 19, and teaching–learning methods using mobile devices such as smartphones and tablet PCs are also garnering attention [23]. In particular, if the game-style cognitive learning program presented in this study is utilized in a digital medium, educational applications tailored to individual characteristics can be grafted, which can arouse improved interest in the cognitive learning activities of the subjects compared to conventional cognitive training programs [24,25].

Endeavor Rx, a game-based software program for treating ADHD, was developed in the United States for children aged 8–12. It is a cognitive training program using digital media [26]. Endeavor Rx has been approved by the U.S. Food and Drug Administration (FDA) and has been proven to be appropriate for use in digital therapeutics to improve the cognitive functioning without space constraints; thus, it can remedy the shortcomings of conventional cognitive training programs [27]. As such, it is considered a serious game to improve the quality of real life through training using digital media [28]. In addition to Endeavor Rx, AKL-T01 (Akili Interactive, Boston, MA, USA), a video game for treating autism, and Autism Therapeutic (Cognoa, Palo Alto, CA, USA), an AI-based customized behavioral therapeutic program for children with developmental disabilities, promote interest in learning and motivate the subjects to participate in learning, which leads to improved learning capabilities [29,30].

According to a prior study that applied game-based cognitive training to five children with intellectual disabilities, children's IQ significantly increased after a game-based cognitive training that maintained or improved verbal understanding, perceptual reasoning, working memory, and processing speed of cognitive area [31]. Studies on children without disabilities and with intellectual disabilities have also confirmed that game-based cognitive training can provide meaningful improvements in the cognitive abilities, working memory, and perceptual reasoning skills; it has also been confirmed that such training is suitable for online contents, which are generally easy to use [32]. Game-based cognitive training has been confirmed to be appropriate for children with intellectual disabilities, and VR and computer game-based cognitive training have also been shown to improve visual perception and behavioral functions in these children [33]. The possibility of game-based cognitive training as a cognitive rehabilitation tool was confirmed by verifying significant differences before and after intervention of game-based cognitive training programs through analysis of Mini-Mental State Examination (MMSE) [34]. In addition, a study on 20 students with intellectual disabilities found that by increasing concentration through video games, perception ability improved, which in turn led to an improvement of their learning ability [35]. Although game-based cognitive training programs have been reported to induce interest and be effective in different target groups and have the possibility to be applied at home, research on children with intellectual disabilities is insufficient.

Therefore, this study compared the effects of improving the cognitive ability using conventional cognitive training program groups and experimental groups that use the *Neuro-World* cognitive training program that graft AI, big data analysis, and 3D game technologies. It is intended to prove that the game-based cognitive training program has a learning effect like the existing training tools for children with intellectual disabilities.

2. Materials and Methods

2.1. Participants

In this study, we recruited 60 children aged 6–13 years and who had been diagnosed with congenital intellectual disabilities based on intelligence tests—Korean Wechsler Intelligence Scale for Children IV (K-WISC-IV)—at pediatric psychiatry departments of university-based or general hospitals. The participants were selected based on criteria specified in prior research [32]. Based on Cohen's sampling program, i.e., the G*power 3.1.9.7 program (University of Kiel, Kiel, Germany), when the effect size, significance level, and test power are 0.5, 0.05, and 0.80, respectively, the minimum number of subjects must be 51. However, 60 were selected in this study, considering a dropout rate of 20%. The criteria for selecting children were as follows: (i) IQ < 70 as per an intelligence test (K-WISC-IV) conducted by mental health clinical psychologists, (ii) developmental delay or retardation or intellectual disabilities, as diagnosed by a specialist, (iii) sufficient hearing to recognize sound effects from software, (iv) no prior experience of participating in other AI-based cognitive training programs, (v) intention to participate in research, and (vi) written consent from a legal representative.

However, children with a history of mental illness, those currently taking psychotropic drugs, those with orthodontic vision and hearing problems, and those with difficulty moving both arms or both hands were excluded. The 60 children with intellectual disabilities who participated in the study were equally divided into experimental and control groups through random sampling by drawing lots. There was no significant difference in age and sex between the two groups ($t = -1.25$, $p < 0.05$) and between the evaluation scores ($t = 1.93$, $p < 0.05$). The characteristics of the children with intellectual disabilities who participated in this study are shown in Table 1.

Table 1. Generic characteristics of the subjects.

Classification	Diagnosis	Average Age (SD)	Gender (Male/Female)	Average IQ (SD)	The Existence of *Neuro-World* Program Experience	Other Problems
Experimental group	Intellectual disabilities	8.83 (1.79)	23/7	62.1 (2.60)	No	No
Control group		9.57 (2.17)	19/11	60.3 (4.51)	No	No

(N = 60).

2.2. Measurement

In this study, K-WISC- IV was used as a pre- and post-test tool. This intelligence test is the Korean version of WISC -IV which was revised in 2011 and can assess the cognitive abilities of children from aged 6–16 years and 11 months [36,37]. K-WISC-IV is used as a method for calculating a full-scale IQ (FSIQ) by summing four cognitive ability scores (average = 100, standard deviation = 15)—verbal understanding, perceptual reasoning, working memory, and processing speed [38]. In addition, it consists of 15 subtests (average conversion score = 10, standard deviation = 3), of which 10 are core subtests items and 5 supplemental subtests items.

K-WISC-IV can provide a comprehensive assessment of the overall cognitive function and is also available as part of an assessment tool to identify cognitive strengths and weaknesses in children with neuro-developmental disorders, gifted children, ordinary children, and children with low intellectual abilities in the intellectual spectrum [39]. In addition, it is a useful evaluation tool for outlining treatment plans or educational placement decisions at clinical and educational sites [40]. In this study, it was used to check the cognitive levels of children with intellectual disabilities and to identify changes in the cognitive capabilities before and after intervention in the *Neuro-World* cognitive training program and conventional cognitive training programs.

2.3. Interventions

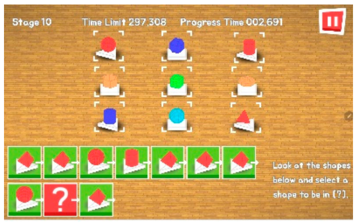
2.3.1. Neuro-World Cognitive Training Program

The *Neuro-World* cognitive training program, developed by Woori Soft Co., Ltd. (Daegu, South Korea), is a service to provide suitable education considering the individual characteristics of elderly people with dementia, or children and adolescents with intellectual disabilities, communication deficiencies, or psychological problems. The program is a cognitive training software developed by grafting advanced ICT technologies such as AI, big data, and 3D game technology using cognitive rehabilitation science.

Neuro-World is a game training program that uses digital media such as Endeavor Rx, which can be easily used without restrictions on space such as home or school. It is considered more practical and effective than conventional cognitive training programs because the participating children show more interest and voluntarily participate due to the element of games. Specifically, this program uses an AI module that customizes the difficulty level as per the users' ability and intensively proceed their inadequate sections, based training data regarding initial performance. It reduces the training duration; moreover, the cognitive abilities of children with intellectual disabilities can be judged more objectively. On the other hand, most existing digital-based cognitive rehabilitation programs are in the form of quizzes; hence, their range of changes in methods of progress can be limited; additionally, being single-form training methods, such programs are less self-active and lack in its adaptability to changes. However, *Neuro-World* can be effective for children with intellectual disabilities, as various forms of learning are possible because training tools are created by learning forms through AI systems.

In this study, the cognition training program was conducted in the form of an online provision method using a tablet PC and a smart device; the latter was a Samsung Galaxy Tab S7 (SM-T976M. 2020). The *Neuro-World* cognitive training program consists of four major cognitive areas—memory, attention concentration, visual perception, and execution—and six sub-items: visual perception, target memory, selective and continual attention, search and observation, and daily task planning. The composition and contents of the program are shown in Table 2.

Table 2. Examples of composition of the *Neuro-World* cognitive training program.

(**a**) Visual perception memory	(**b**) Target memory	(**c**) Selective attention concentration
		
(**d**) Continual attention concentration	(**e**) Search and observation	(**f**) Daily task planning
		

(**a**) Visual perception memory: by identifying the direction in which the target animal disappeared and allowing it to perform spatial position retrospection tasks, it improves automatic processing ability of visual information and the ability to recognize and retrospect. This area is matched with picture completion among the sub-items of the intelligence test. Picture completion corresponds to perceptual reasoning among cognitive areas. (**b**) Target memory: improve the ability to store and output visual information by checking whether the target animal has disappeared and allowing it to perform retrospection tasks. This area is matched with digit span and letter-number sequencing among the sub-items of the intelligence test. Digit span and letter-number sequencing correspond to working memory among cognitive areas. (**c**) Selective attention concentration: among various information, it enhances selective attention concentration by allowing visual search-oriented problem-solving tasks to pay attention to the target information. This area is matched with block design and matrix reasoning among the sub-items of the intelligence test. Block design and matrix reasoning correspond to perceptual reasoning among cognitive areas. (**d**) Continual attention concentration: among various information, it enhances the attention concentration by continuously paying attention to the target information and allowing them to perform visual search-oriented problem-solving tasks. This area is matched with arithmetic and digit span among the sub-items of the intelligence test. Arithmetic and digit span correspond to perceptual reasoning among cognitive areas. (**e**) Search and observation: it increases the visual discrimination ability by performing visual discrimination tasks, which involves the finding of a target animal. This area is matched with picture concepts among the sub-items of the intelligence test. Picture concepts corresponds to perceptual reasoning among cognitive areas. (**f**) Daily task planning: it increases the self-control ability by giving daily life tasks, remembering all about them, and letting them perform voluntarily. This area is matched with comprehension, vocabulary, letter-number sequencing, symbol search among the sub-items of the intelligence test. Comprehension and vocabulary correspond to verbal understanding, letter-number sequencing corresponds to working memory and symbol search corresponds to processing speed among cognitive areas.

2.3.2. Conventional Cognitive Training Program

Conventional cognitive training programs are also called Tabletop activities [41]. Such training programs consist of planar activities, which are two-dimensional media that use paper or pencils [16]. In this study, items that are similar to items of the *Neuro-World* cognitive training program were chosen and applied to conventional cognitive training programs. The major training items were memorizing picture card positions, memorizing face cards, puzzle making, counting activities, finding the same picture activities, and sequence card activities.

2.4. Procedure

Participants in this study were children with intellectual disabilities who voluntarily participated through recruitment announcements of six child development clinics in a particular city. Considering that the subjects of this study were vulnerable children aged 6 to 13, not only participants but also legal guardians were explained the necessity and procedures of the study in detail, and it was conducted after obtaining written consent. The experiment was conducted in the treatment room of each child development clinic, which was a quiet place equipped with desks and chairs to conduct cognitive training programs.

All 60 children with intellectual disabilities underwent intelligence tests (K-WISC-IV) before and after the intervention. Sixty children were divided into two equal sized groups. One group participated in the *Neuro-World* cognitive training program, while the other group participated in the conventional cognitive training programs. Both groups were fully acquainted with the methodological aspects of the program through practice before performing the cognitive training program, and the experiment was conducted in a total of 24 sessions, twice a week and eight times a month from August 2020. Rehabilitation experts who conduct pre- and post-training evaluations were blind to group assignments because they had no involvement in setting up this experimental method.

The experimental group was trained for four major cognitive areas—memory, attention concentration, visual perception, and execution—and six sub-items: visual perception, target memory, selective and continual attention, search and observation, and daily task planning. The order of progress was assigned randomly.

The initial progression of the *Neuro-World* cognitive training program is in the order (a)–(b)–(c)–(d) in Figure 1. First, the participants logged in using their personal account, as shown Figure 1a. At this time, the personal accounts were encoded numerically to comply with privacy standards. Second, one major cognitive area of the subject's choice had to be selected. As shown in Figure 1b, the main screen of the game has four major training areas and three sub-items for each area. Third, the subjects were required to click on the game description for the selected cognitive area for learning how to play the games and choose a suitable level. At this time, the rehabilitation specialist verified that the subjects were fully familiar with the training methods for the corresponding cognitive area through exercise and training. Fourth, a step selection screen appeared as shown in Figure 1d, and the cognitive rehabilitation specialist directly decided when the subjects were trained for the first time and made them start from the first level. From the second session, AI was used to analyze the data and automatically determine the lacking areas of cognitive ability and the appropriate level for users.

Figure 1. Initial progression page of the *Neuro-World* cognitive training program. (**a**) Login page, (**b**) main page of game, (**c**) page for selecting level of each game and game description page, (**d**) page for selecting level for games.

The four cognitive areas in which the steps were set were tested. There is a total of 6 sub-items of the Neuro-World program for a total of 4 cognitive areas, and training was conducted for 5 min for each of the sub-items, for a total of 30 min. The time for each subarea was automatically set. After 5 min, the program automatically moved on to the next area. All cognitive areas were set from Level 1 to Level 20. When a correct response was provided, an audio-visual signal was shown; the correct answer was displayed when an incorrect response was provided.

Figure 2 shows examples of some of the steps performed in the sub-items.

Figure 2. Examples of game progression screen in the *Neuro-World* cognitive training program. (**a**) Visual perception memory (Level 10), (**b**) selective attention concentration (Level 10), (**c**) search and observation (Level 20), (**d**) daily task planning (Level 20).

The assessment and arbitration of all the experiments were conducted by researchers, co-researchers, and three cognitive rehabilitation experts with more than five years of experience. Three cognitive rehabilitation experts were provided with detailed explanation of the purpose of the study, research procedures, precautions, and methods of use, to improve their understanding of the experiment. In addition, cognitive rehabilitation experts were blind to group assignment as they were not involved in processes of group assignment.

2.5. Data Analysis

In this study, descriptive statistics and one-way analysis of variance (ANOVA) were used to indicate differences between and within the groups in the *Neuro-World* training program and the conventional cognitive training programs. SPSS Statistics 23 was used for data analysis.

3. Results

3.1. Differences between Groups Using the Neuro-World Cognitive Training Program and Conventional Cognitive Training Program

The differences between groups in the *Neuro-World* cognitive training program and in the conventional cognitive training program are shown in Tables 3 and 4.

There was no significant difference between the pre-score (M = 62.1) of the *Neuro-World* cognitive training program group and the pre-score (M = 60.3) of the conventional cognitive training programs group (F = 3.87, p < 0.05, *Cohen's d* 1.0226). However, it was significant between the post-score (M = 65.4) of the *Neuro-World* cognitive training program group and the post-score (M = 60.1) of the conventional cognitive training programs group (F = 33.71, p < 0.05, Cohen's d = 2.0499).

Table 3. Results of descriptive statistics of differences between pre-/post-group.

Classification		N	M	SD	SE	95% Confidence Interval for the Mean		Minimum	Maximum
						Low	High		
Preintervention	Experimental group	30	62.1	2.155	0.393	61.29	62.90	58.00	66.00
	Control group	30	60.3	4.519	0.825	58.61	61.98	53.00	70.00
	Total	60	61.2	3.625	0.468	60.26	62.13	53.00	70.00
Postintervention	Experimental group	30	65.4	2.459	0.448	64.51	66.35	60.00	69.00
	Control group	30	60.1	4.432	0.814	58.36	61.69	53.00	69.00
	Total	60	62.7	4.466	0.605	61.59	63.90	53.00	69.00

Table 4. Results of analysis of variance between pre-/post-group.

Classification		Sum of Squares	Degree of Freedom	Mean Square	*F*	*p*-Value
Preintervention	Intergroup	48.60	1	48.60	3.877	0.054
	Intragroup	727.00	58	12.53		
	Total	775.60	59			
Postintervention	Intergroup	432.01	1	432.01	33.623	0.000 *
	Intragroup	745.23	58	12.84		
	Total	1177.25	59			

* $p < 0.05$.

3.2. Differences within Groups in Neuro-World and Conventional Cognitive Training Programs

The differences within groups in the *Neuro-World* cognitive training program are shown in Table 5. The average score (M = 65.4) of post-intervention in this group showed an average of 3.3 points higher than the average score (M = 62.1) of preintervention, exhibiting a statistical significance between these scores ($F = 31.176$, $p < 0.05$).

Table 5. Differences between pre- and post-intervention of experimental group.

Classification	Pre-Intervention	Post-Intervention	*F*	*p*-Value
	M(SD)	M(SD)		
Neuro-World cognitive training program	62.1 (2.60)	65.4 (3.39)	31.176	0.000 *

* $p < 0.05$.

The differences in sub-items in the groups in the *Neuro-World* cognitive training program are shown in Table 6. The score decreased by 1.2 points from 20.7 to 19.5 in the verbal understanding section, and by 1 point from 21.8 to 20.8 in the perceptual reasoning section. In contrast, the working memory section shows an increase by 3.2 points from 10.0 to 13.2, and the processing speed section shows an increase by 2.5 points from 10.5 to 13.0. In other words, a statistically significant difference was observed between the pre-and post-scores of verbal understanding, working memory, and processing speed ($F = 29.207$, $F = 10.909$, $p < 0.05$).

The differences within groups in the conventional cognitive training programs are shown in Table 7. The post-intervention score of the conventional cognitive training programs group was 0.2 points lower than the pre-intervention score, was not significant ($F = 0.041$, $p < 0.5$).

The differences in sub-items within a group in the conventional cognitive training programs are shown in Table 8. As shown, the scores decreased by 0.3 points from 19.8 to 19.5 in the verbal understanding section but increased by 0.2 points from 18.9 to 19.1 in the perceptual reasoning section and by 0.1 points from 10.9 to 11.0 in the working memory section. There was no change in the processing speed section. In other words, the scores in all these sections were statistically insignificant (F = 0.149, F = 0.032, F = 0.017, F = 0.000, p > 0.05).

Table 6. Results of intelligence test (K-WISC-IV) sub-items on preintervention and postintervention of the *Neuro-World* cognitive training program.

Classification		M	SD	*F*	*p*-Value
Verbal understanding	Preintervention Postintervention	20.7 19.5	3.1 3.4	2.874	0.950
Perceptual reasoning	Preintervention Postintervention	21.8 20.7	4.2 4.8	1.624	0.208
Working memory	Preintervention Postintervention	10.0 13.3	2.1 2.6	29.207	0.000 *
Processing speed	Preintervention Postintervention	10.5 13.1	3.0 3.0	10.909	0.002 *

* $p < 0.05$.

Table 7. Differences with pre- and post-intervention of control group.

Classification	Pre-Intervention	Post-Intervention	*F*	*p*-Value
	M(SD)	M(SD)		
Conventional cognitive training program	60.3(4.51)	60.1(4.89)	0.041	0.841

$p < 0.05$.

Table 8. Results of intelligence test (K-WISC-IV) sub-items on preintervention and postintervention of the conventional cognitive training programs.

Classification		M	SD	*F*	*p*-Value
Verbal understanding	Preintervention Postintervention	19.8 19.5	3.6 3.7	0.149	0.701
Perceptual reasoning	Preintervention Postintervention	18.9 19.1	3.7 3.6	0.032	0.860
Working memory	Preintervention Postintervention	10.9 11.0	3.0 3.0	0.017	0.897
Processing speed	Preintervention Postintervention	10.6 10.6	3.3 3.0	0.000	1.000

$p < 0.05$.

4. Discussion

This study was conducted to analyze the effectiveness of game-based cognitive training programs in improving the cognitive abilities of children with intellectual disabilities. A group of 30 children using the *Neuro-World* game-based cognitive training program and a group of 30 children using conventional cognitive training programs were evaluated for intelligence (K-WISC-IV) through pre- and post-intelligence tests. The results indicated that the difference in the average scores for the pre-/post-tests were not significant for the conventional cognitive training program group. However, for the *Neuro-World* group, the average score for the post-test was significantly better than that for the pre-test. Among the four sub-items in K-WISC, neither the conventional cognitive training program group nor the *Neuro-World* group showed any significant score change in verbal comprehension and perceptual reasoning. However, with regard to working memory and processing speed, significant improvements were observed for the *Neuro-World* group but not for the conventional training group. Thus, the *Neuro-World* cognitive training program can be considered more effective than conventional cognitive training programs. However, it is necessary to consider the increase in the frequency of intervention sessions, given that intervention in children with intellectual disabilities is a long-term and continual approach.

The significant difference in working memory and processing speed section is attributed to the association between the working memory and processing speed section with four major sub-items (memory, attention, visual perception, and performance ability) of the *Neuro-World* cognitive training program. It can be said that the working memory is the ability to solve various cognitive tasks by actively accessing information while temporarily remembering visual and spatial information [42]. From this perspective, the memory (position memory, target memory) section training of the *Neuro-World* cognitive training program seems to enhance the ability to temporarily remember visual and spatial information, improving the working memory ability. Processing speed can be defined as the amount of time required to make a correct judgment on visual stimuli [43]; in other words, the ability to exactly remember the purpose to carry out, carefully perceive whether currently ongoing tasks correspond with the purpose, and make accurate judgments in a short time [44]. Since this can be seen as related to all four major sub-items of the *Neuro-World* cognitive training program, it seems that children who participated in the study improved their processing speed.

Considering that children with intellectual disabilities can experience difficulties in responding to rapid progress in most intervention programs, the *Neuro-World* program showed significant changes over a three-month period and is expected to continue being adopted for cognitive and learning interventions for children with intellectual disabilities. Through this study, when used as a game-based cognitive training tool for children with intellectual disabilities, it is proved to be effective, like existing tools, and is considered to be used as a training learning tool for children with intellectual disabilities in a non-face-to-face in the future.

Limitations

On the other hand, the reason for the relatively low improvement in verbal understanding is that the corresponding training program in *Neuro-World* is being still developed; hence, it was excluded in this study. Moreover, the scores for perceptual reasoning exhibited less variation than those for working memory and processing speed did because perceptual reasoning training programs had been partially excluded from this study. As the cognitive training time was limited to 30 min and each item was allocated five minutes, items that affect working memory and processing speed appeared to have been focused on more. Therefore, further research should be conducted on the sub-items related to verbal understanding and perceptual reasoning.

In this study, the experiments of the *Neuro-World* cognitive training program group and conventional cognitive training programs group conducted a total of 24 sessions, twice a week and eight times a month, and it was confirmed that the cognitive ability of the *Neuro-World* cognitive training program group was improved by performing six training items. If, in contrast to this study, the training is conducted for longer than three months, the degree of cognitive improvement might be more significant than the one revealed by our findings. In addition, to further increase the motivation and attention concentration of children with intellectual disabilities, training methods that are conducted in the form of receiving certain rewards each time they clear the stage are considered to be more effective [45].

More subjects are needed due to the small number of subjects in this study and additional training sessions considering the small change in the level of progress of children with intellectual disabilities are required for more significant results. The absence of language sub-items in the *Neuro-World* program constitutes a limitation in presenting the relevance of verbal understanding in K-WISC, which is used as an effectiveness assessment tool for the cognitive training program. In addition, variables of demographic information such as familiar socio-economic status and parental education were not included in this study. Furthermore, it is necessary to develop additional motivational factors that can encourage children with intellectual disabilities to show interest and enhance their attention span.

5. Conclusions

In this study, the possibility of game-based cognitive training programs being used as practical and effective tools for improving cognitive abilities of children with intellectual disabilities was confirmed. In addition, considering the average improvement of 3.3 points in the evaluation score and the rise in the stage of progress, the *Neuro-World* program can be expected to generate more interest from subjects compared with conventional cognitive training methods. Moreover, considering the opinions of the legal representatives of the subjects, the *Neuro-World* program can be used as a non-face-to-face intervention assistive tool at home.

Author Contributions: S.-C.K.; project administration, H.-s.L. and S.-C.K.; investigation, S.-C.K. and H.-s.L.; writing—original draft preparation, S.-C.K.; writing—review and editing. methodology—H.-s.L. Both authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the Technology Innovation Program-Advanced Technology Center + (Project No. 20014295) funded by the Ministry of Trade, Industry & Energy (MOTIE, Korea).

Institutional Review Board Statement: This study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of Keimyung University Dongsan hospital (2020-09-032-002) (2020/10/15).

Informed Consent Statement: All study participants, or their legal guardian, provided informed written consent prior to study enrollment.

Data Availability Statement: Data is contained within the article.

Conflicts of Interest: The authors declare no conflict of interest.

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