Development of Computer-based Visual Perception Test Program for Korean Patients with Brain Injury

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ABSTRACT

Up to now, several tools to evaluate visual perception tests have been introduced for different purposes. However, they were mostly manual tools, paper books in which the therapists would turn the pages while working together with patients. This paper discusses a potential plan to develop motor-free visual perception test software for Korean patients with brain injury, and to construct a centralized database for their evaluated data in a client/server environment. Through its development, we eventually hope to achieve effective management of the data for better understanding of patients' visual perceptual skills and the standardization of the evaluation for Korean patients. With the help of the computerized environment, we also expect some advantages such as acquisition of reliable results from patients with brain injury, automation for storing and accessing patients' data, construction of the patients' database and the management of a vast amount of the data within it and the provision of a foundation to promote further development of various perceptual-cognitive rehabilitation programs.

***Keywords**: Brain, cognitive science, visual perceptions, client-server systems.*

1. INTRODUCTION

Visual Perception is ability that analyze visual information about things that accept through eye in automatic nervous system. That is, Visual Perception refers to ability that recognize and discriminate, and analyze combining with virtue experiences visual stimulation. Because analysis for visual stimulation happens in brain and not in eye, brain injury badly affects human visual perceptual ability. From psychological approaches, visual perceptual skills are taken into account in terms of visual closure, figure-ground discrimination, form consistency, spatial relations, and position in space. Visual perception test tools aid to evaluate visual perceptual skills for patients having brain injury and compare the resulting data with normal persons'.

Several standardized tools to evaluate the skills have been introduced for different purposes. However, they were mostly paper materials or books, which a number of pictures are included as evaluating sources. By these tools, therapists show and explain each page to the patients and evaluate their reactions manually. Typical examples are DTVP (The Developmental Test of Visual Perception), TVPS (The Test of Visual Perception Skills), MVPT (Motor-free Visual Perception Test), and so forth. A major problem of manual tests pertains to the reliability of the data obtained through the evaluation process. Test results might be different, dependent on, for instance, who evaluates. Computers could be tools of great use by which manual tools are replaced with, reducing errors committed by manual tests. They also provide a more seamless and effortless way to store patients' data. Furthermore, since construction of patients' database is possible, it would be a baseline to understand and analyze their data.

This paper describes a potential plan to build a computerized environment for the visual perception test. My plan is, on one side, to develop a computer-based motor-free visual perception test program. On the other side, we will also try to build a client/server environment so that patients' data obtained by the client program could be stored in a database server. When the program and the environment are well-established, we expect several advantages to follow

2. BACKGROUNDS

2.1 Brain Injury

Jean Ayres described in her landmark book Sensory Integration and Learning Disorders [1], "the overall function of the brain is to filter, organize and integrate sensory information to make an adaptive response to the environment" (p21). Adaptation is not only the ability to survive in the environment, but to act it: to manipulate, mold, and improve one's existence. The brain receives isolated bits of information and puts these pieces together or integrates them to provide a complete and

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continuously updated picture of the environment [2]. In particular, visual information in complex and pervasive circumstances plays a crucial role to prepare a basic sensory system in the overall process of survival and adaptation.

Vision has long been viewed within the medical and psychological field as being comprised of two distinct functions: the ability to see objects and the ability to perceive/interpret what is seen. Visual perception is an ability to interpret visual information through eyes in a central nervous system, and its function can be conceptualized and organized as a hierarchy of processes that interact with and subserve each other [2].

Cerebral vascular accident (CVA) and traumatic brain injury (TBI) are main diseases in brain dysfunction. CVA is a complex dysfunction caused by a lesion in the brain. TBI typically results from accidents in which the head strikes an external physical object. CVA results in upper motor neuron dysfunction that produces hemiplegia or paralysis of one side of the body. It may also bring about some problems in responding to the sensory stimuli appearing in the affected side, and also in processing sensory information such as visual field deficits, hemianopsia, decreased body scheme, decreased right-left discrimination, impaired visual integration, and apraxia. In addition, cognitive activities pertaining to orientation, memory, and attention could be deteriorated. Even personal interaction and functional performance in everyday activities sometimes show difficulties. In fact, visual perceptual skills of people with head injury affect functional performance in activities of daily living, work, and leisure. An evaluation of visual perceptual ability is important to set therapeutic goals and approaches, and to give us basic data so as to improve functions and quality of life for clients.

The traditional psychological approach views visual perception as being comprised of a series of discrete skills. Terms such as visual closure, figure-ground discrimination, form consistency, spatial relations, and position in space have been employed to describe these skills. Other terms like visual object agnosia have been also coined to describe impairment in the skill following brain injury.

2.2 Visual Perception Test Tools

Time that Visual Perception development consists very fast being 7-year-old 6 months interval in 3-year-old 6 months, do that is completed to arrive to 10 years old to 11 years old [3]. Visual Perception's proficiency helps that child learns to read, write, build, count, and develop other all functions that need to learning. Therefore, as character studying ready function the importance of development of Visual Perception ability is emphasized among much Perception developments. We have need of Visual Perception test that can confirm first development level of Visual Perception ability and obstacle existence and nonexistence [4]. It is utilized by treatment method through proofreading of Visual Perception obstacle or Visual Perception training program that clear cause and special quality of Visual Perception obstacle through Visual Perception test.

Development of visual perceptual tests have been used to measure skills, as well as, comparing the performance of individuals with brain injury to their non-injured counterparts, with the intent of establishing norms for perceptual behavior.

There have been standardized tools introduced to measure visual perceptual ability: The Developmental Test of Visual Perception (DTVP), The Test of Visual Perceptual Skills (TVPS), The Benton Form Discrimination Test, The Hooper Visual Organization Test, and Motor-Free Visual Perception Test (MVPT).

The Developmental Test of Visual Perception (DTVP) is a tool to distinguish children with and without visual impairment. Facing environmental change, DTVP-2 has also been developed as a new form of DTVP to understand the extent of impairment for eye-hand coordination as well as for visual perception [5]. For children that are from 4 to 12 years of age, The Test of Visual Perceptual Skills (TVPS) has been designed to evaluate visual perceptual ability, e.g. visual discrimination, visual memory, spatial relations, form consistency, position in space, visual closure and figure-ground discrimination.

The Benton Form Discrimination Test helps to measure discrimination of visual form [6]. The Hooper Visual Organization Test examines the ability of integration concerning sensory information acquired through a series of pictures [7]. People between the ages of 13 to 69 years of age can make use of this test. Motor-Free Visual Perception Test (MVPT) has been developed for children and adults respectively. Through the children's version, one can assess the visual perceptual skills for children between the ages of 4 to 11 years of age. The adult version was designed for the people with brain injury, concerns of spatial relation, visual discrimination, figure-ground discrimination, visual closure, and visual memory. Test results show that one can obtain useful information about the degree of the brain injury, the speed of visual information processing, and unilateral inattention.

Table 1. Kind of a standard visual perception test tools

Test Tools	Target	Contents
DTVP (Developmental Test of Visual Perception)	4-9 age	Visual-Motor coordination, figure-ground discrimination, form consistency, spatial relations, position in space
VMI (Developmental Test of Visual-Motor Integration)	3-14 age	24 geometrical figures
MVPT(Motor Free Visual Perception Test)	4-8 age adult	spatial relations, figure-ground discrimination, visual closure, visual memory
TVPS (Test of Visual Perceptual Skills)	4-12 age	visual discrimination, visual memory, spatial relations, form consistency, visual closure, position in space, figure-ground discrimination

PMDT (Perceptual-Motor Development Test)	3-11 age	Perception test (figure-ground discrimination, analysis of figure, combination of figure), Motor Test (line drawing, dot drawing)

Table 2. Visual-motor coordination visual perception test tools

Type	Item	Explanation
Visual-Motor coordination	16	Coordination of eye and hand (line drawing/ join point)
Figure-Ground perception	14	Ability that search feeling form being piled up include within background
Perceptual Constancy	18	Ability that recognize basic attribute of particular type rightly and distinguish (Shape/size/position) – use a figure
perception of position in Space	8	perception ability of Position (reverse/Turning) – use of Familiar general things diagram
perception of Spatial Relationships	8	Form analysis ability through line drawing that join point like presented pattern

Table 3. Motor-free visual perception test tools

Type	Item	Explanation
Spatial Relationship	9	Ability measuring that can analyze simple form within space
Visual Discrimination	6	Figure distinction ability measuring within other form (Position/shape/form/color/ character form)
Figure-Ground	7	Figure-ground distinction ability measuring within picture
Visual Closure	12	Ability that recognize basic attribute of particular type rightly and distinguish
Visual Memory	6	To find after remember picture that see first

2.3 Measurement Item of Visual Perception Test

2.3.1 Visual-motor coordination test (total 64 Item)

- level 1 : Visual-Motor Coordination 5 item
- degree of difficulty : Space

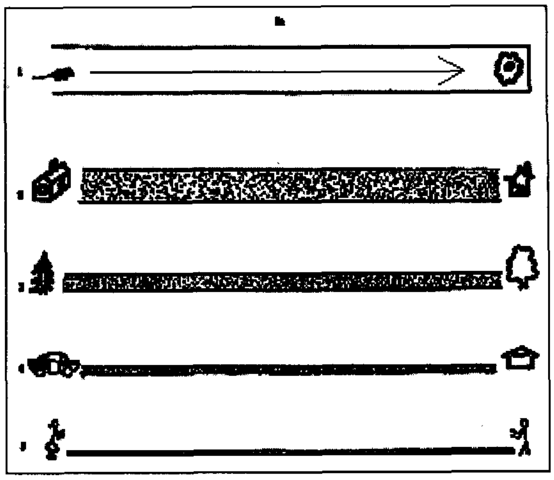

Fig. 1. To draw connection line

- level 2 : Figure-Ground Perception 2 item
- degree of difficulty : Complexity

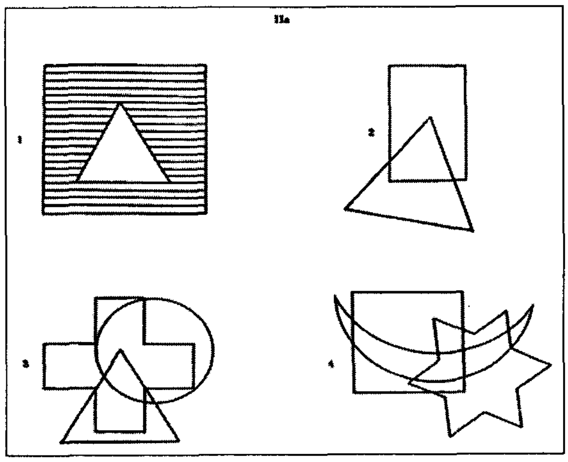

Fig. 2. To discriminate figure

- level 3 : Figure Perceptual Constancy 2 item
- degree of difficulty : Complexity

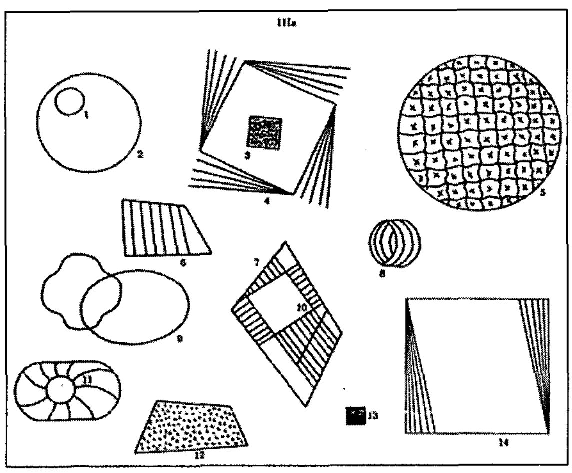

Fig. 3. Figure Perceptual Constancy

- level 4 : Perception of Position in Space 2 item
- degree of difficulty : Complexity

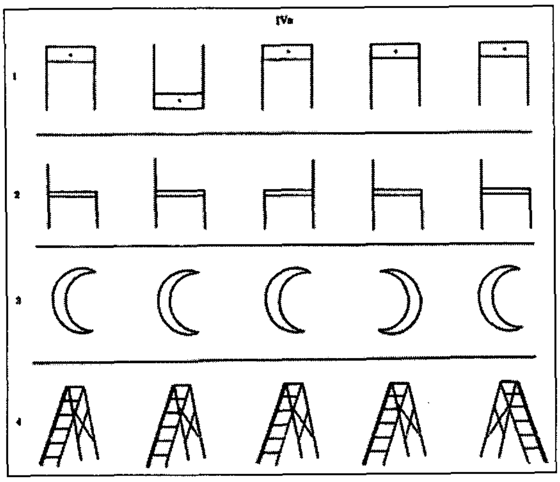

Fig. 4. Perception of Position in Space

- level 5 : Perception of Spatial Relationships 5 item
- degree of difficulty : Complexity

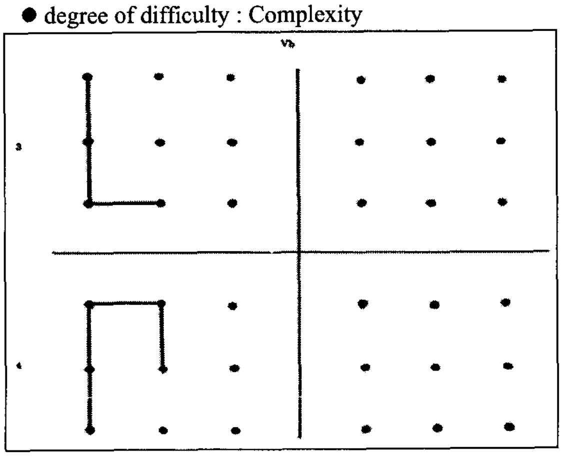

Fig. 5. Perception of Spatial Relationships

2.3.2 Motor free visual perception test (total 40 Item)

- level 1 : To find same form 5 item
- spatial relation, position in space, figure-ground distinction, mixing perception

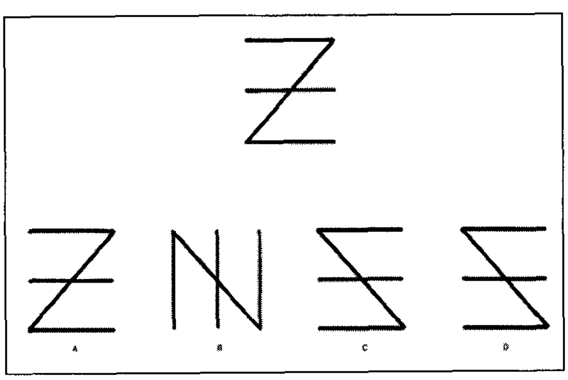

Fig. 6. To find same form

- level 2 : Visual discrimination 5 item
- spatial relation, position in space, figure-ground distinction, mixing form discrimination

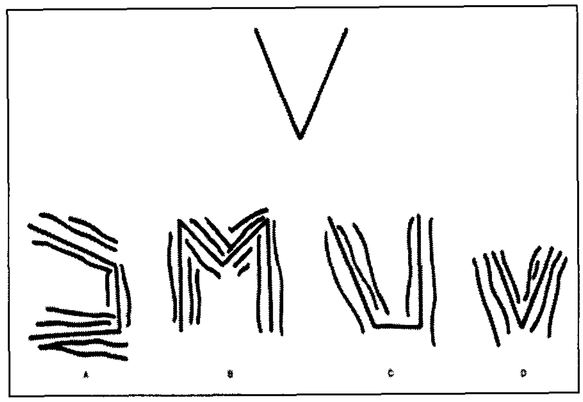

Fig. 7. Visual discrimination

- level 3 : Visual memory 8 item
- spatial relation, position in space, figure-ground distinction, figure memory

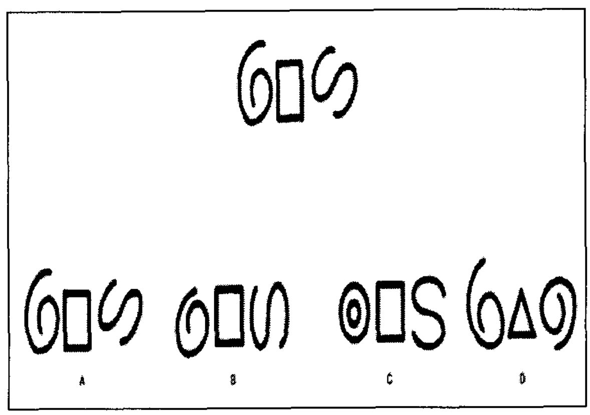

Fig. 8. visual memory

- level 4 : Visual closure 13 item
- visual closure, spatial relation, position in space, figure analogical inference

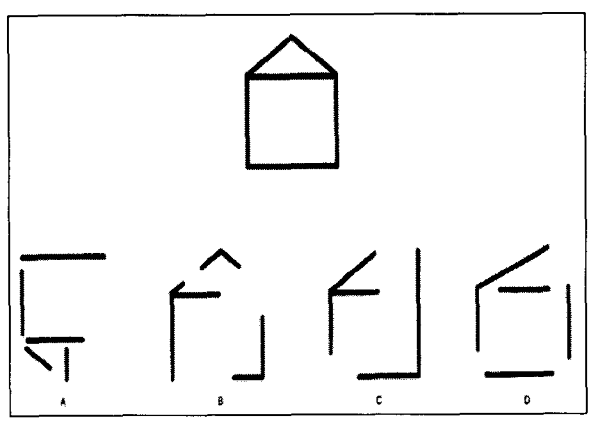

Fig. 9. visual closure

- level 5 : To find different form 5 item
- spatial relation, position in space, figure distinction

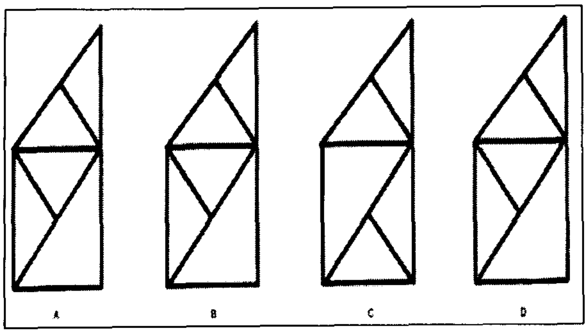

Fig. 10. To find different form

3. COMPUTER-BASED VISUAL PERCEPTION TEST

Standardized tools for the visual perception test, aid to check if and to what extent visual perceptual ability is impaired in more objective manners, as well as providing a foundation to measure the extent to which the ability has changed. Most tools, however, have been designed to evaluate children alone, or otherwise to assess limited particular skills [8].

In addition, test tools are paper books including pictures, as contents required for the visual perception test. Rapid development of IT has brought about substantial change of our everyday living environments. Computers already became tools which people use and interact with, and make it possible to store and manage a large number of data and communicate between people. Computers are particularly useful machines which may replace various manual ways of evaluating. We can gain some merits by the usage of the computerized environment for the visual perception test as follows:

Firstly, it is possible to reduce the errors of therapists. It is well-known that manual evaluation of visual perceptual skills tends to result in assessment errors. Assessment results may differ, dependent on who evaluates. There are also problems in measuring a certain time manually, for example, a reaction time of a patient to visual stimuli. In that respect, we have a better chance to interpret the patients' data which are more reliable, valid, and objective by usage of the test software.

Secondly, we can easily store and access to the data, which to some extent, eventually leads to the automation of processes. Undoubtedly, statistical analysis generated by the computer is also plausible.

Thirdly, patients' data accumulated by the computer will be a great source in helping to understand their visual perceptual skills. When a system is developed as a client-server system, the data from all patients who use visual perception test software (client software) are sent to a central database server so that these data might be integrated and managed effectively in one common place. Consequently, by building a database where a huge amount of data from a large number of people is stored, researchers and therapists have a better opportunity to use and analyze the data. It actually facilitates the studies of patients and helps to give a better understanding to their visual perceptual skills.

Fourthly, it also promotes the development of various computer-based training programs for cognitive-perceptual rehabilitation. These include edutainment software and contents which could be used to develop visual perceptual skills, particularly for children and patients.

4. A PROPOSED SYSTEM

As we mentioned it before, visual perception test highly relies on tools consisting of paper materials. In fact there is no computer-based evaluation tool over the world, only the German version of DTVP. Therefore, it is now an urgent task to computerize the test environment so that one could gain a number of benefits described previously.

With the potential of computerization, we plan to develop a motor-free visual perception evaluation software for Korean patients. This plan primarily includes two major objectives: construction of a centralized management system of patients' data, and a standardization of the evaluation. Coinciding with these goals, we are to develop a client-server system.

4.1 System overview

The system that we propose in this paper is a client-server system where users, both therapists and patients, who have access right, are allowed to use the client program for the visual perception test. When they complete a test via the program, the evaluated results will be sent to a central DB server. That is, the evaluation and statistical analysis will be performed by the use of the client program for accuracy, with the results being sent to the server. Therefore, each single action of the users who make use of the client program is not sent in real-time, and it is only once after the completion of their actions that they are sent to and recorded in a DB server. By doing this, one may reduce server overload and maintain accuracy of the evaluation; for instance the accuracy of response time to the stimuli. Without a doubt, people having access accounts could be tested for their own or their patients' visual perceptual skills through an on-line evaluation, wherever they are. The data can also be easily sent to and collected in a central DB server.

4.2 Construction of patients' database

When the client software for the evaluation is utilized in institutes, hospitals, and the like, entire data from an extensive amount of people, is assembled and managed at one place in the DB server. As an inevitable consequence, the vast amount of data collected would be a highly useful resource in analyzing and understanding the visual perceptual ability of patients with head injury.

Importantly, the patients' DB plays a crucial role in understanding the visual perceptual ability from various angles, for instance, according to different regions, periods, categories, and so forth. It also provides us further development of new cognitive-perceptual rehabilitation programs to improve visual perceptual skills.

4.3 Standardization of evaluation

A major goal in this project is to achieve standardized ways of evaluating visual perceptual ability of Korean patients with brain injury. However, this goal cannot be fulfilled without thorough scientific analysis. It certainly needs more cautious approaches to develop evaluation software that provide the standardized method of assessing.

Firstly, it is inevitable to test validity and reliability regarding contents for the evaluation. Particularly, more efforts are requested to uncover the assessment contents that are suited to Korean patients.

Secondly, it is also requested to understand the differences between the paper-based and computer-based tests. The difference of usage of media between paper and computers has gained interest from researchers, especially from human factors researchers [9-11]. When media used to evaluate change, the assessed results may be different due to distinct characteristics of different media. Therefore, a precise understanding of media differences is a foremost task in order to build the standardized method of evaluating the visual perceptual skills for Korean patients with brain injury.

5. CONCLUSION

We have briefly shown in this paper potential to develop a client-server system for a visual perception test for Korean patients with brain injury. In comparison with paper-based tests or evaluations currently employed, computer-based ones offer us certain benefits like the acquisition of reliable results, automation for storing and accessing patients' data, construction of patients' database and centralized management of a massive number of data, and the provision of a foundation to launch development of various perceptual-cognitive rehabilitation programs. In order to provide standardized ways of evaluating Korean patients, thorough scientific analysis is required to support validity, reliability, and usability. Importantly, when shifting from paper to computers, we need to capture a precise understanding of the difference of usage of two different media in this context. There is a still a large amount of work to examine scientifically and empirically remaining.

REFERENCES

[1] A. J. Ayres, Sensory Integration and Learning Disorders, Los Angeles: Western Psychological Services, 1972

[2] M. Warren, "Visuospatial skills: assessment and intervention strategies." AOTA Self-Study Series: Cognitive Rehabilitation. The American Occupational Therapy Associate, Inc, 1994

[3] Ronald P. Colarusso & Donald D. Hammill, "MVPT-R Manual", Academic Therapy Publications, pp.11, 1996

[4] Gwang-eung Yeo, Theory and truth of Visual Perception Training Program, Seoul,: Paideia , pp.13-14, 1994

[5] D. D. Hammill, N. A. Pearson, and J. K. Voress. Developmental Test for Visual Perception. Second edition (DTVP-2) Stoelt Co. 1998

[6] A. Benton, et al. Contributions to Neuropsychological Assessment: A Clinical Manual. New York: Oxford Press. 1983

[7] H. E. Hooper, The Hooper Visual Organization Test. Los Angeles: Western Psychological Services. 1996

[8] B. C. Abreu and J. P. Toglia, Cognitive Perceptual Rehabilitation Manual. New York Hospital-Cornell University Medical Center.

[9] C. Haas, "Does the medium make a difference? Two studies of writing with pen and paper and with computers" Human-Computer Interaction, vol. 4, 1987, pp. 149-169

[10] A. Dillon and S. Maynard. "Don't forget to put the cat out – or why collaborative authoring software and everyday writing pass one another by!" New Review of Hypermedia and Multimedia, Applications and Research, vol. 1, 1995, pp. 135-153

[11] A. Sellen and R. Harper, "Paper as an analysis resource for the design of new technologies" in Proceedings of CHI '97. Atlanta, GA:ACM, 1997, pp. 319-326

[12] Marianne Frostig, "Marianne Frostig Developmental Test of Visual Perception", Consulting Psychologists Press, 1964

[13] Seong-hye Ahn, Eun-hwan Kang, "A study of the importance for multimedia implementation of Developmental Test of Visual Perception", proceeding of spring conference of Korean society of design science, 2003

[14] Seong-hye Ahn, "Elicitation Elements and Variables for a Prototype Development of Visual Perception Test Program", proceeding of spring conference of Korea multimedia society, Vol.6 No.1, pp. 401-404, 2003

[15] Seong-hye Ahn, "Development of Graphic Item for Visual Perception Test Program", proceeding of spring conference of Korea society

[16] Hwa-moon Bak, Bon-guen Koo, VMI ; Developmental Test of Visual-Motor Integration, Seoul: a book concern education for the handicapped, 1990

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