DEVELOPMENT OF STEREOSCOPIC ALPHABET LITERACY LEARNING SYSTEM FOR CHILDREN WITH DEVELOPMENTAL DYSLEXIA

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Abstract: A unique stereoscopic system has been developed to support intelligible understandings of alphabet characters. The system is consisted of ordered pair of strokes with distinct depths, which might be useful to help the learning for children with developmental dyslexia. We showed previously the effectiveness for hiragana learning (Yamazoe et al. 2009), but not yet for the alphabet learning. Thus, we have evaluated a literacy learning system with normal subjects in the present study. Clean advantages of stereoscopic perceptual recognition over the flat recognition are obtained for alphabets as well as hiragana, suggesting the effectiveness of stereoscopic learning, irrespective of dialogue characters.

1 INTRODUCTION

Developmental dyslexia is a specific learning disability that is neurobiological in origin (Lyon et al. 2003). It is a phonological deficit characterized by difficulty distinguishing speech sounds (phonemes) aurally and as represented in written language. One of the deficits in children with developmental dyslexia involves the ability to analyze component phonemes of words, sometimes referred to as phonemic awareness. Indiviuals with developmental dyslexia in Japanese character have recognition problems is decomposing characters into their components, patterns, or strokes. Children with developmental dyslexia often showed difficulties for the understanding of the aggregated structure of characters at the beginning of their writing. These factors are believed to contribute to impeded acquire literacy skills. In schools, literacy learning are processed through two steps: students look a model of character with guidance, and then followed the shapes exactly. This school literacy learning method may not be suitable for children with developmental dyslexia. Thus literacy education materials had been designed specific for children with developmental dyslexia. Only planar materials such as paper and flat displays are however, used at traditional literacy education, inspire of taking long period to acquire.

People with developmental dyslexia have difficulties acquiring reading and writing skills, some show impressive talents in various fields. Authors focus one of dyslexia ability which is phenomenal visuo-spatial recognition abilities(von Károlyi et al. 2003). Visuo-spatial recognition is required to understand the three-dimensional position of an object, which contains ample information than 2D objects. People with developmental dyslexia is able to recognize the structures of characters much easier in a way of stereoscopic 3D displays. Especially authors are

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interested in the relationship between stereoscopic vision and spatial perception. Stereoscopic vision uses parallax for space perception. In the stereoscopic researchs, the efficacy of stereocopic information : Nakayama et al. (1989) reported that less periods are recognized to finde at a target among a set of distractors was shorter if the target was in a front rather than a rear stereoscopic plane. Shigeta et al. (1996) also showed that stereosocpic, rather than flat, presentation is suitable for character.

The authors have developed a literacy learning system to present hiragana characters on a stereoscopic 3D display (Yamazoe et al. 2009). The stereoscopic system is consisted of ordered strokes with distinct depths. These results suggest a possibly of the stereoscopic vision as a tool to learn hiragana character writing for developmental dyslexia. The aim of this study is to test the efficacy of the system as a tool in the literacy learning of other languages. In the present study, we have proposed the advantage of a stereoscopic 3D display system for supporting the alphabet character education for children with developmental dyslexia in compared with flat characters.

2 PROPOSED LITERACY LEARNING SYSTEM

2.1 Stereoscopic 3D Display

A stereoscopic 3D display is effective for people to recognize 3D patterns like a real world objects and 3D images. Most stereoscopic 3D displays are able to recreate distinct depth objects simultaneously and this easier for us to recognize information. In general stereoscopic 3D display by which two images of the same object taken at slightly different angles are viewed together, creating an impression of depth. Such image differences in the binocular retina are referred to as binocular disparity. This mechanism is known to cause visual fatigue as a result of poor accommodation and convergence (Hatada 1988). Due to the problems with asthenopia, stereoscopic 3D displays are not widely used for educational purpose.

A depth fused-3D (DFD) display, rather than commonly used stereoscopic 3D display has been used in the present study to minimize asthenopia. Figure 1 shows the principle of a DFD display, which presents natural stereoscopic images without the need for special glasses (Suyama et al. 2000). The DFD display consists of a stack of two transparent displays that project images from the front and rear. Those two 2D images are the same shape, which are almost overlapping from the observer’s perspective. As shown in figure 1, the observer perceives the depths of an object depending on the ratio of the luminance in the two displays caused by a visual illusion. Controlling the luminance of the two 2D images at nearest values will produce images at intermediate depth. These two 2D images produce a stereoscopic image that is continuous in the depth direction. In this stereoscopic vision mechanism, the line of sight converges on the screen images according to the distance from a target objects, hence there is not discrepancy between accommodation and convergence in human visual function.

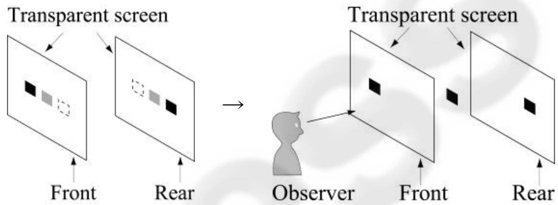


Figure 1: Principle of a Depth fused 3D Display. The luminance ratio of the front and rear rectangles changes.

2.2 Image of a Stereoscopic Character

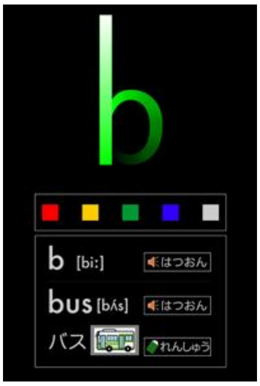
Figure 2 shows an example of stereoscopic character. Stereoscopic characters were rendering by a 3D software (Autodesk 3ds Max 2009). Stereoscopic characters are consisted of ordered pair of strokes and depth for easily to recognize structure of characters. DFDs Depth is set to correlate color values with the front to rear. Gradation (0 (black) to 255 (white)) is able to make continuously depth changing.

Figure 2: Image of a stereoscopic character.

2.3 The Contents for Alphabet Literacy Learning

Figure 3 shows the contents of literacy learning for alphabet. Two contents were prepared: one showed the alphabet learning contents (Figure 3a) and the other shows English word leaning contents (Figure 3b). Each content are show together with a handwriting space. A man of learning starts to operate the control button on the screen through the mouse. Clicking the pronunciation button begins the learning session. Other content is appeared by clicking the practice button.

The literacy learning content was created by using Flash MX 2004 (Macromedia). Content was run on standalone Flash Player 9 used swf format (Macromedia).



a. The alphabet learning.

b. English word learning.

Figure 3: The contents for literacy learning alphabet. The color button changes the character color (red, yellow, green, blue, white).

3 EXPERIMENT

3.1 Subjects

Nine subjects (four female and five males) aged between 19 and 25 took part in this experiment. All of the subjects had normal visual acuity, either natural or corrected using glasses or contact lens. The subjects agreed to participate in the study after being given a brief description of the experiment. Before the experiment, the subjects were asked to write the characters they learned in the experiment, and also the stroke order was checked. The subjects were able to write the correct stroke.

3.2 Apparatus and Stimuli

Figure 4 shows the experimental apparatus. The stimuli were displayed on a 9-inch DFD display (Hitachi Displays, Ltd.) at distance of 50 cm. The stimuli were generated from flash player and literacy learning content formatted swf on a notebook computer (Sony, Pentium M 1.86 GHz, Windows XP Professional). Figure 5 shows the alphabet stimuli. Stimuli were image of stereoscopic characters (figure 5: B-start and B-end) and a flat character. The screen background was black (RGB 0). Two stereoscopic characters consisted of ordered pair of color values and depth: B-start as correlated front to rear with a starting stroke point to end stroke point with continuously changed. B-end as correlated rear to front with starting stroke point to end stroke point with continuously changed. A flat character was rendering only white color on the front panel of DFD. Character used “y” and “b”. The characters consisted of “y” drawn with straight lines and “b” drawn with a straight line and a curve.

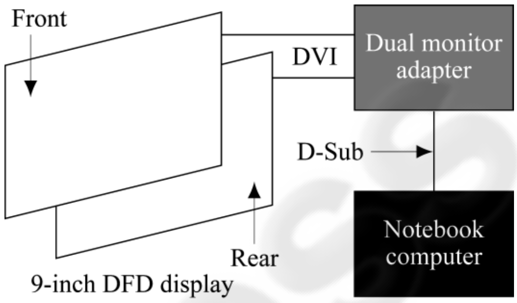


Figure 4: The experimental apparatus.


a. B-start


b. B-end

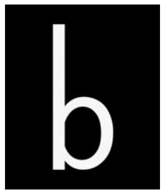

c. Flat character

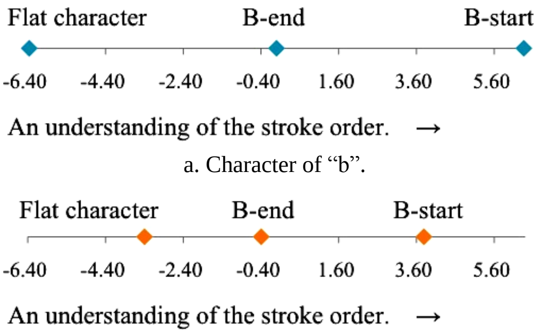
Figure 5: The parameters of stimuli. a. Stereoscopic character: Brighten as start to darken as end (B-start). b. Stereoscopic character: Brighten as end to darken as start (B-end).

3.3 Procedure

Stereoscopic stimuli were shown with each alphabet on DFD. B-start, B-end and flat were shown side by side at random combination between the same alphabet. Subjects watch combination of characters total 6 times. Subject answered, “Which alphabet character’s writing order is understandable?” after alphabet characters combination watched. In this experiment “An understanding of the stroke order.” meanings how easily to recognize to correct stroke order.

3.4 Results

The results were shown in figure 6. The horizontal axis was extents of understandings of the stroke order. Levels of understanding increasing from left to right. Each subject's recognition of understandings was analyzed by Thurstone's Paired Comparison. B-start was significant difference from others. B-end was significant difference from flat character. Two characters was not significant difference between "b" and "y". The subjects answered several comments about the understanding of the stroke order used stereoscopic character. Subjects answer was including "The stroke order is known", "The stereoscopic character is understandable", "It is legible" and "The line is clear and understandable".



a. Character of "b".

b. Character of "y".

Figure 6: Experimental results.

4 CONCLUSIONS

As shown in figure 5, the stereoscopic 3D display was compared to the flat display for character-comprehension tests. The data obtained suggest that stereoscopic depth is a key factor to recognize character efficiently. Although the exact reason for the preferred left-start remained unclear, it might be associated with natural order sense for depth perception. In fact, some subjects felt a start–stroke point as protruding at B-start, and thus readily recognize the writing begins. In the present study, clean advantages of stereoscopic perceptual recognition over the flat recognition are obtained for alphabets as well as hiragana. These data suggest that stereoscopic 3D display is a promising tool for the effective character learning, irrespective of dialogue characters.

Literacy learning system incorporating many visual elements may be effective to support the understanding of the stroke order even for children with developmental dyslexia. It is possible that, by arranging alphabet characters spatially, subjects are able to obtain information more efficiently than that few flat presentations. The present system with stereoscopic character has possibility to fix the character in long-term memory. Subjects did not complain visual fatigue while watching characters on a DFD display. The stereoscopic characters may be easy to recognize as DFD display. From these results, authors propose that alphabet characters are readily recognized on a DFD display at a stereoscopic character of B-start. To further improve stereoscopic literacy learning system, authors is currently have a plan to evaluate children with developmental dyslexia. This experiment did not investigate a learning effective of the literacy learning system, which is a subject for future investigation.

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