Literacy Learning Program using 3D Kanji Models for Children with Developmental Dyslexia

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Abstract
A unique program for the 3D representation of letters (including stroke order and structure) has been developed to support intelligible understanding of written Japanese kanji by children with developmental dyslexia using a tablet computer. The 3D kanji consists of ordered pairs of strokes with distinctly different depths. This study therefore aims to test the efficacy of the program as a tool for literacy learning on a tablet computer. We propose that the 3D program better supports Japanese kanji education for children with developmental dyslexia as compared to 2D letters. In the present study, the effect of 3D letters on kanji learning and subjective preferences about kanji learning methods for children with developmental dyslexia and typically developing children were tested. Five children with developmental dyslexia and five typically developing children participated in this study. Participants used both 3D kanji and 2D kanji. The post-tests were conducted immediately after learning and every week for four weeks. The post-test conducted immediately after writing indicated that the writing order was more accurate for 3D kanji than 2D kanji. The correct answers were different for each participant after four weeks of learning kanji. The data obtained suggested that 3D depth is a key factor in the efficient recognition of letters. It is possible that arranging 3D letters spatially helped the participants to obtain information more efficiently than from flat presentations. The 3D kanji might be a fun method for children to learn kanji, irrespective of learning disabilities.

Keywords: dyslexia, kanji, literacy learning, 3D, learning disabilities

Introduction

Developmental dyslexia is a learning disability that is neurobiological in origin (Lyon, Shaywitz, & Shaywitz, 2003). Learning to read or to write is extremely difficulty for about 80% of those suffering from learning disability (Lerner, 1989). Individuals with developmental dyslexia have recognition problems when decomposing Japanese characters into their components, patterns, and strokes.

The Japanese writing system consists of two qualitatively different scripts: *kanji* and *kana*. Kanji are both logographic and morphographic and are derived from Chinese characters. Japanese children are introduced to 1006 different kanji characters during their six years of primary school education. Japanese children with dyslexia have more trouble writing kanji than reading it. This difficulty appears in various ways, such as difficulties separating kanji characters into their component strokes, failing to grasp the aggregate structure of characters, orienting them incorrectly, and omitting certain strokes.

The traditional methods used to teach children the Japanese writing system are often unsuitable for children with developmental dyslexia. Teachers most commonly begin instruction by showing students a specific kanji character and teaching them the phonetics of this character. Teachers then demonstrate the stroke order of the character so that students can follow their example. Finally, children repeatedly practice the characters to master them. This traditional method refers to copying a visually displayed model. Due to their writing impairments, children with developmental dyslexia often show a poor response to this method of learning kanji (Uno et al., 2009). Nevertheless, it is also reported that individuals with developmental dyslexia have phenomenal visual-spatial recognition ability (von Károlyi, Winner, Gray, & Sherman, 2003). Visuo-spatial recognition is required to understand the three-dimensional(3D) position of an object, which contains more information than two-dimensional (2D) objects.

We developed a literacy learning program using 3D kanji models. This study aims to test the efficacy of this literacy learning program on a tablet computer. We propose that 3D letters better support Japanese language education for dyslexic children compared to 2D letters.

Methods

Participants

The participants of this study include six children with low vision (three boys and Five children with developmental dyslexia (four boys and one girl) between eight and ten years of age and five children without developmental dyslexia (two boys and three girls) between six and seven years of age participated in this study. Written informed consent was obtained from the participant's parents. This study was approved by Sagami Women's University.

Apparatus and Stimuli

This experiment was conducted on a tablet computer (9.7-inch Apple iPad Air). The learning kanji in both 3D and 2D were presented the using the Apple iBooks application. The participants were asked to seat themselves on a chair positioned in front of the tablet computer.

This study used 3D software (Autodesk Maya) to model the 3D letters. The 3D letters were COLLADA format (.dae). This content involved 3D letters that were created using the 3D widget within iBooks Author (Apple).

The 3D letters were correlated front to rear with a starting-stroke point to end-stroke point that continuously changed (see Figure 1). These were arranged in the depth direction (z-axis) in combination with the stroke order. The 3D letters can rotate 360 degrees on the screen. The 2D letters were the same as the kanji models(Koubunshoin) used at school (see Figure 2). This study selected the learning kanji which the participants never learn to kanji.

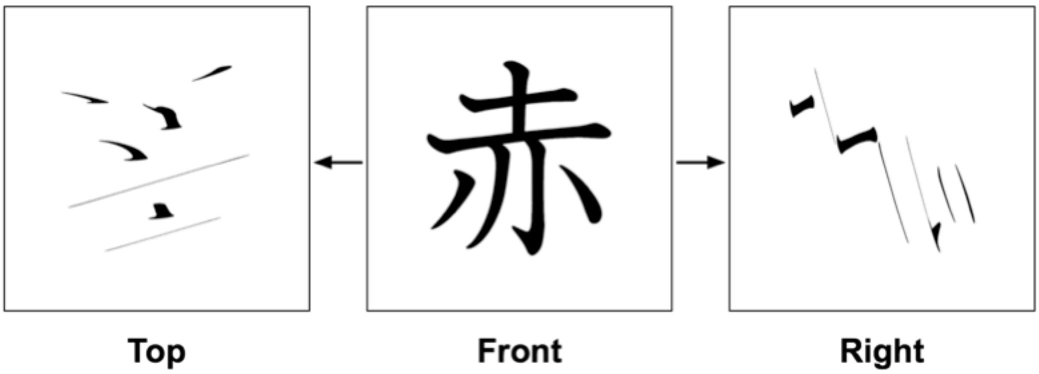

Figure 1: The 3D letter of “ 赤(red)”.

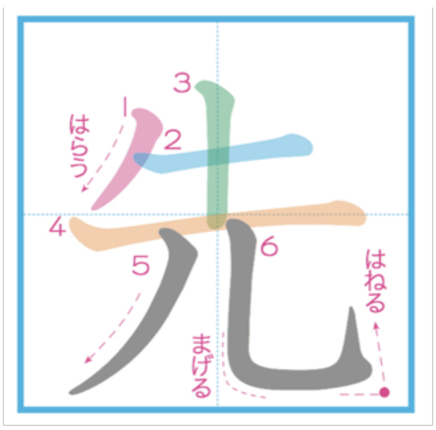

Figure 2: The 2D letter of “ 先(tip)”.

Procedure

The participants sat on a chair, and they were provided with instructions for the task. They learned using 2D or 3D kanji on a tablet computer; they copied the kanji five times on paper while looking at a 2D or 3D kanji models. One session was two letters of a 2D or 3D kanji while a limited 5 minutes. The participants were conducted two sessions.
Figure 4 shows a participant learning the 3D kanji. The participants were tested on the learned kanjis immediately after learning them (post-test) and one week later (post-test 2).

Figure 3: Participant learning the 3D kanji on an iPad.

Results

Post-test 1 results for developmental dyslexia were an average of 60.0±24.4% for 2D and 100.0±00.0% for 3D kanji. Post-test 2 results for children with developmental dyslexia were an average of 30.0±20.0% for 2D and 90.0±10.0% for 3D kanji.

Post-test 1 results for the control group were an average of 30.0±12.2% for 2D and 50.0±0.0% for 3D kanji. Post-test 2 results for the control group were an average of 0.0%±0.0 for 2D and 10.0±10.0% for 3D kanji.

We checked that participants recalled the learned kanji after using the 2D or 3D kanji. In children with developmental dyslexia, the 3D kanji scored higher than the 2D kanji in post-test 2 ($p < 0.10$, n = 5; Wilcoxon signed rank test, $z = -1.73$, two-tailed).

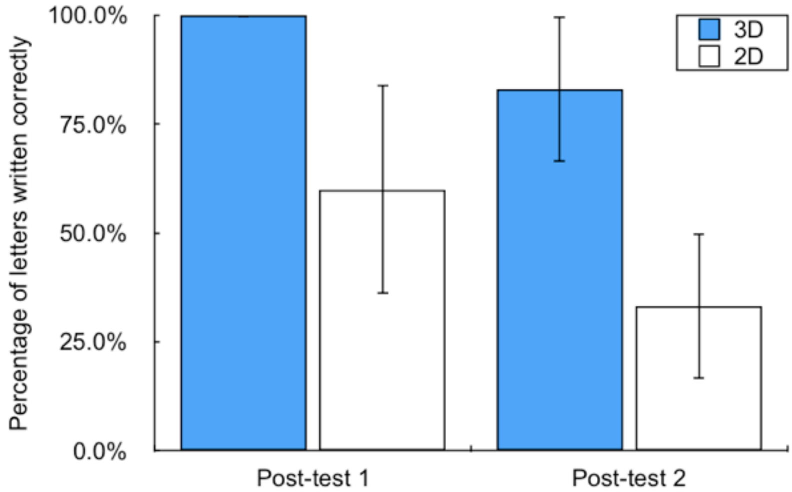

Figure 4: Writing skill assessment test in children with developmental dyslexia.

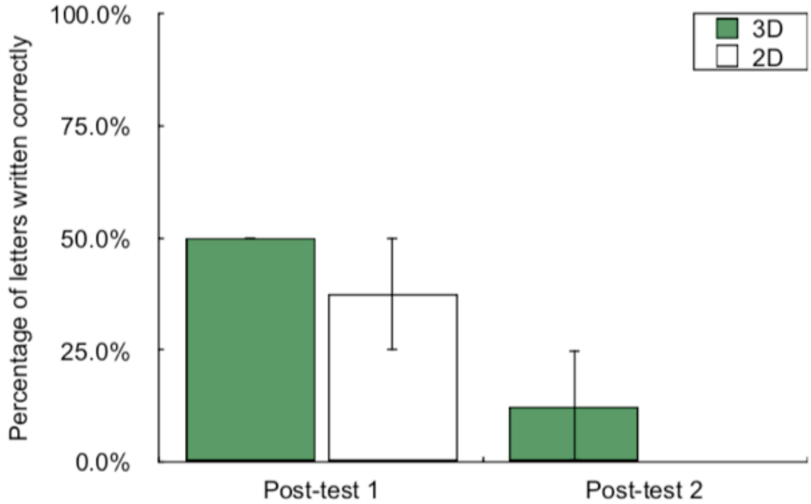

Figure 5: Writing skill assessment test in controls.

Conclusion

We discovered that 3D letters are suitable for children with developmental dyslexia to obtain enough visual information and that this is a useful tool for learning kanji letters. These 3D kanji characters have been proven to be an effective method for delivering visual information to children with developmental dyslexia.

Japanese kanji consist of more strokes than letters in the English alphabet. The visual characteristics of Japanese kanji might account for the difficulty of memorizing the script. This experiment with 3D kanji has indicated that using depth information, shapes, and positions made the text easier to grasp.

The current results suggest that depth information is a key factor in the effective recognition of kanji letters. It is possible that by arranging 3D letters spatially children with developmental dyslexia were able to obtain information more efficiently than from 2D letters.

In the future, we plan to investigate the effectiveness of this 3D program among dyslexic language learners who are struggling with other languages.

Acknowledgment

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