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Multimedia Redundancy Effect in Learning Chinese with Pinyin

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Abstract: The reported study was aimed at developing effective techniques for reducing learner cognitive overload while using pinyin (a phonetic system) to learn Chinese language. Learning effects of two instructional conditions (character-pinyin-pronunciation and character-pronunciation) were compared for learners with different levels of prior Mandarin proficiency and pinyin knowledge. It was expected that the effectiveness of eliminating redundant on-screen pinyin might depend on levels of learner prior knowledge. Results demonstrated superiority of the character-pronunciation condition over the character-pinyin-pronunciation condition for learners with a lower prior knowledge level. No differences between the two conditions were found for learners with higher levels of prior knowledge.

Keywords: Multimedia, cognitive load, learning Chinese, pinyin, redundancy.

Introduction

This study is conducted within the framework of cognitive load theory which is an instructional theory based on assumptions that humans have a very limited working memory capacity for processing novel information and that learning becomes ineffective if the demand for cognitive resources exceeds this limit [1,2]. However, working memory capacity could be effectively expanded by optimizing the involvement of two relatively independent sub-systems of working memory, one responsible for dealing with visual information and another for processing auditory information [3,4]. Also, the available organized knowledge base in long-term memory allows us to chunk elements of information in working memory into larger higher-level structures and process them as single units, thus reducing working memory load [5].

This study investigated the effectiveness of using pinyin in learning Chinese characters from the perspective of cognitive load theory. Pinyin represents one of the phonetic systems used to support learning Chinese [6]. Pronunciation information conveyed by characters is very limited because of their ideographic nature [7]. It is therefore conventionally believed that pinyin should accompany characters because it provides accurate pronunciation of Chinese characters. In practice, pinyin is often used simultaneously with its auditory pronunciation. However, in some conditions, this practice may possibly hinder learning characters due to multimedia redundancy effect in cognitive load theory.

According to the modality effect in cognitive load theory, presenting a diagram (picture) with written explanatory text could be less effective than presenting the diagram with spoken explanations. In a single-modality presentation format, the visual channel of working memory might become overloaded, whereas in a dual-modality format, working memory capacity could be effectively expanded by combining the partially independent visual and auditory processing channels. However, simultaneously presenting both written and spoken explanations of a diagram could be detrimental for learning (a multimedia

redundancy effect [8]). Additional cognitive activities involved in processing the redundant written explanations and cross-referencing them with spoken explanations may impose additional wasteful cognitive load that would overload working memory and interfere with learning.
Therefore, a concurrent presentation of a character (pictorial representation), pinyin (written verbal representation), and its auditory pronunciation (spoken verbal representation) might impose an unnecessary cognitive load on learners and thus eliminate any potential benefits of using pinyin. The visual pinyin could be regarded as a redundant source of information in this situation that might potentially inhibit learning. However, available studies have demonstrated that the effectiveness of most methods for reducing cognitive load depend on levels of learners' prior knowledge [5]. The purpose of the present study was to investigate if multimedia redundancy and expertise reversal effects would apply to young native Chinese learners with prior exposure to Mandarin in learning Chinese vocabulary. It was assumed that learner familiarity with pinyin and Mandarin would be an important factor influencing the instruction effectiveness of pinyin.

1. Method

1.1 Participants

Ninety-six Cantonese speaking Year 2 students from two Hong Kong subsidized primary schools participated in the study. Sixty-one students (28 male and 33 female, average age 8.72 years *SD* = 0.85) indicated in the questionnaire that they had studied in Mainland China and communicated with their family members (native Mandarin speakers) in Mandarin. These participants with prior exposure to spoken Mandarin were selected as participants in the experiment. The average length of their Mandarin training at the school by the time of the experiment was 3.9 (*SD* = 1.73).

1.2 Materials and Procedure

The experiment included a pre-test phase, a learning phase, and a posttest phase. The pretest phase was conducted in a normal classroom setting in one single session of 25 minutes. The learning and test phases were conducted in a language laboratory in one single session of 35 minutes.

1.2.1 Pretest

The paper-based pretest consisted of three sets of items which were used to evaluate the level of participants’ prior knowledge in pinyin reading skills and Mandarin proficiency. The first two sets of items were multiple-choice questions. The first set included five items and was used for evaluating students’ knowledge of Mandarin pronunciation of some Chinese characters used in learning materials (homophones or share syllable). Students were asked to circle a correct Mandarin pronunciation corresponding to the vocabulary they were instructed to read. The second set included five items and was used to evaluate students’ familiarity with pinyin. Students were requested to correlate a written pinyin with a pronunciation they heard. The third set of items was a listening comprehension test (a short passage with 73 characters). Each response in the pretest was scored 1 (correct) or 0 (incorrect) for the first two sets of items. No score was given if participants selected more than one answer. A maximum score of 5 could be obtained for the listening comprehension question and a maximum of 15 could be obtained if all items were answered correctly. Participants were listed in ascending order according to their pretest scores and alternatively allocated to two different experimental conditions.

1.2.2 Learning Phase

Sixteen two-character words (vocabulary) were selected for learning. The words were presented using PowerPoint on the computer screen. A vertical layout was chosen for presenting the characters and pinyin for the character-pinyin-pronunciation group, and the pinyin was presented just underneath the corresponding character. This format was considered as more effective than alternate prevailing format that placed the pinyin horizontally next to the characters due to the elimination of split attention effect (for more details, see [9]).

The flow of the presentation was the same across each word and instructional format. For example, for each word in the character-pinyin-pronunciation instructional format, only the characters were first shown on the screen for 4 seconds with a voice-over pronouncing the word in Cantonese. Then a blank screen was shown with Cantonese voice-over to explain the meaning of the word. This phase lasted for five to fifteen seconds, depending on the length of the explanation. Then, during the following 14 seconds, the words were presented with pinyin for the character-pinyin-pronunciation condition (characters only for the characters-pronunciation condition), with another voice-over pronouncing the word in Mandarin for three times. The PowerPoint slides changed automatically. The total time allocated for reading one word was set to18 seconds in each condition.

1.2.3 Posttest

A test consisting of four sets of items was designed to measure recall and listening comprehension. The first two sets including eight multiple-choice items were recall questions that required knowledge of the corresponding characters and pronunciation in Mandarin. Participants were told not to make random choices if they did not know the answer. Each response was scored 1 (correct) or 0 (incorrect). The maximum score of 8 could be obtained if all the answers in this test were correct. The following two sets were listening comprehension tasks. In the first set, students were instructed to read six characters that they have learned in the learning phase before listening to a recorded short sentence. They were then asked to identify two characters that they heard. Each full correct response was scored 2. Students were told that no score would be allocated for this question if more than two characters were circled. Another question required students listen to a short passage with 25 characters and answer short questions. The passage consisted of five two-characters words that were selected from the learning materials. Each response was scored 2 (correct) or 0 (incorrect). The maximum score of 8 could be obtained if all answers in these two sets of listening comprehension tasks were correct. The maximum score of 16 could be obtained if all answers in the posttest were correct.

1.2.4 Rating of Cognitive Load

Immediately after the test, each participant was instructed to estimate how easy or difficult it was to answer the questions on a nine-point scale by circling one of the nine numbers from 1 (extremely easy) to 9 (extremely difficult). The scores obtained from this rating scale were used as indicators of cognitive load associated with test performance. Subjective measures of cognitive load have been extensively used in research within a cognitive load framework (see [10] for an overview of the studies).

2. Results

The dependent variables under analysis were overall posttest scores, posttest scores for separate sets of items (i.e., recall tasks and listening comprehension), and subjective ratings of cognitive load. Independent variables were instructional formats (characters-pinyin-pronunciation, character-pronunciation) and levels of learner expertise (lower and higher level).

2.1 Posttest Results

The pretest scores for all 61 participants were arranged in an ascending order and divided into two groups according to the following rule: participants who obtained scores 7 or below belonged to the lower prior knowledge level group, $n = 33$; participants who obtained scores 8 or above belonged to the higher prior knowledge level group, $n = 28$ (a median split).

Two-way ANOVA (learner level of expertise X instructional conditions) indicated no significant main effect for instructional conditions on overall posttest scores, $F(1, 57) = 0.92$, $MSE = 3.82$ ($M = 7.37$, $SD = 2.60$ for the character-pinyin-pronunciation group and $M = 8.03$, $SD = 1.83$ for the character-pronunciation group). There was significant main effect for learners' prior knowledge levels, $F(1, 57) = 7.31$, $MSE = 30.21$, $p < .01$, $\eta_p^2 = 0.11$ ($M = 7.15$, $SD = 2.20$ for the lower expertise level; $M = 8.43$, $SD = 2.06$ for the higher expertise level). There was a significant interaction between the two instructional conditions and levels of learner expertise for overall posttest scores, $F(1,57) = 6.68$, $MSE = 27.62$, $p < .05$, $\eta_p^2 = 0.11$ (For the character-pinyin-pronunciation condition, $M = 6.13$, $SD = 2.33$ for the lower expertise level; $M = 8.92$, $SD = 2.11$ for the higher expertise level. For the character-pronunciation condition, $M = 8.00$, $SD = 1.72$ for the lower expertise level; $M = 8.06$, $SD = 2.02$ for the higher expertise level). In regards to simple effects, there was a significant difference between the two conditions for lower prior knowledge level learners. The characters-pronunciation condition outperformed the characters-pinyin-pronunciation condition, $F(1, 31) = 7 .03$, $MSE = 4.06$, $p < .05$, $\eta_p^2 = 0.19$, with no simple effect for higher knowledge level learners.

Further analysis for scores obtained for each set of items measuring recall tasks and listening comprehension using indicated a significant interaction between the two instructional conditions and levels of learner expertise only for the set of items that measured listening comprehension, $F(1,57) = 5.41$, $MSE = 13.15$, $p = < .05$, $\eta_p^2 = 0.09$ (For the character-pinyin-pronunciation condition, $M = 2.40$, $SD = 1.72$ for the lower expertise level; $M = 4.00$, $SD = 1.71$ for the higher expertise level. For the character-pronunciation condition, $M = 3.78$, $SD = 1.35$ for the lower expertise level; $M = 3.50$, $SD = 1.51$ for the higher expertise level) In regards to simple effects, there was a significant difference between the two conditions for the lower prior knowledge level learners, $F(1,31) = 6.62$, $MSE = 2.35$, $p = < .05$, $\eta_p^2 = 0.18$, with no simple effect for higher knowledge level learners.

2.2 Ratings of Cognitive Load

Two-way ANOVA for measures of cognitive load indicated a significant main effect for experimental conditions, $F(1,57) = 4.10$, $MSE = 29.69$, $p < .05$, $\eta_p^2 = 0.07$ ($M = 6.30$, $SD = 2.84$ for the character-pinyin-pronunciation condition; $M = 4.91$, $SD = 2.49$ for the character-pronunciation condition). There was no main effect for levels of learner expertise. There were also no significant interactions between the levels of expertise and instructional designs for measures of cognitive load.

3. Discussion

Overall, the visual pinyin transcription provided in addition to auditory pronunciation of characters did not cause a multimedia redundancy effect in learning Chinese vocabulary by junior primary school students. However, a reduced level of cognitive load during the test for learners in the character-pronunciation condition may imply more efficient learning under this instructional condition than under the character-pinyin-pronunciation condition. The findings also demonstrated an expertise reversal effect according to which the effectiveness of alternative instructional techniques depends on learners' available knowledge structures in long-term memory. In this experiment, learners' familiarity with Mandarin and pinyin could effectively increase working memory capacity to allow processing redundant visual pinyin. The anticipated multimedia redundancy effect with the character-pinyin-pronunciation condition was demonstrated for the lower prior knowledge learners. For these learners, eliminating the redundant information enhanced learning. For learners with higher prior knowledge level, the available knowledge might have allowed effortless processing of the redundant on-screen pinyin. It should also be noted that, aligned with previous studies (e.g., [11]), the multimedia redundancy effect affected only certain aspects of language learning (listening comprehension in this study).

References

[1] Sweller, J., van Merriënboer, J., & Paas, F. (1998). Cognitive architecture and instructional design. *Educational Psychology Review, 10*, 251-296.
[2] Sweller, J., Ayres, P., & Kalyuga, S. (2011). Cognitive load theory. New York: Springer.
[3] Baddeley, A. (1992). Working memory. *Science, 255,* 556-559.
[4] Mousavi, S. Y., Low, R., & Sweller, J. (1995). Reducing cognitive load by mixing auditory and visual presentation modes. *Journal of Educational Psychology, 87*, 319-334.
[5] Kalyuga, S. (2007). Expertise reversal effect and its implications for learner-tailored instruction. *Educational Psychology Review, 19,* 509-539.
[6] Shu, H., Zeng, H. M., & Chen, Z. (1993). 小学低年级儿童利用拼音学习生字词的实验研究. *心理发展与教育 (Psychological Development and Education), 1*, 18-22.
[7] Packard, J. L., Chen, X., Li, W., Wu, X., Gaffney, J. S., Li, H., & Anderson, R. C. (2006). Explicit instruction in orthographic structure and word morphology helps Chinese children learn to write characters. *Reading and Writing, 19,* 457-487.
[8] Kalyuga, S. (2000). When using sound with a text or picture is not beneficial for learning. *Australian Journal of Educational Technology, 16,* 161-172.
[9] Lee, C. H., & Kalyuga, S. (2011, in press). Effectiveness of different pinyin presentation formats in learning Chinese characters: A cognitive load perspective. *Language Learning, 61(4).*
[10] Van Gog, T., & Paas, F. (2008). Instructional efficiency: Revisiting the original construct in educational research. *Educational Psychologist, 43*, 16-26.
[11] Lee, C. H., & Kalyuga, S. (2011). Effectiveness of on-screen pinyin in learning Chinese: An expertise reversal for multimedia redundancy effect. *Computers in Human Behavior, 27,* 11-15.