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The Effectiveness of Visual Instructions in Memorizing Chinese Semantic Radicals for Beginners

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Abstract

The acquisition of thousands of Chinese Characters (CCs) is a big challenge for learners. Chinese Semantic Radicals (SRs) are semantic components of CCs. Memorizing SRs benefits the acquisition of CCs when learning Chinese as a second language. This study investigates the effectiveness of Visual Instructions (VIs) in memorizing SRs for beginners. A preliminary study and three studies were conducted. The results showed that memorizing SRs with color-coded illustrations significantly increased the accuracy of memorizing the meanings, shapes, and positions of SRs in memory tests. The findings are an important contribution to the research of VIs and memorizing SRs for beginners.

Keywords: Information design, visual instructions, color coding, integrated illustrations, Chinese semantic radicals

1. Introduction

Learning Chinese as a second language fosters the development of the economy, culture, and education of the future. Mandarin Chinese was ranked as one of the priority languages in the British Council's report (British Council, 2013, 2017). Chinese Characters (CCs) play an essential role in the acquisition of Chinese as a second language. The knowledge of Chinese Semantic Radicals (SRs) facilitates memorizing CCs, especially for beginners (Lü et al., 2015; Nguyen et al., 2017; Su & Young-

Suk, 2014; Zhang et al., 2016). This study aims to explore Visual Instructions (VIs) for increasing the effectiveness of memorizing SRs for beginners. The measurement of the effectiveness was the percent accuracy in memory tests and the participants' opinions after the memory tests. The CCs and SRs presented and used in this study are simplified scripts that are used in mainland China.

The knowledge of SRs includes their meanings, shapes, and positions (Chen, 1983; Wang et al., 1999). SRs provide constant meanings (Shen & Ke, 2007; Xu et al., 2014). Taking SR Water as an example (Figure 1), CCs Soup and Sea have semantic associations with the meaning of water. Different SRs hold different positions (Shen & Ke, 2007; Xu et al., 2014). Some SRs hold fixed positions in CCs. For example, the SR Water is always on the left of CCs (Figure 1). Some SRs have the same meaning with different positions. For example, SR Heart (vertical) is on the left of CCs, and SR Heart (horizontal) is on the bottom of CCs (Figure 1). In this study, the nomenclature used will be SR [meaning] (vertical) and SR [meaning] (horizontal) if the same-meaning SRs have different positions. VIs aim to effectively present, communicate and memorize information by integrating textual and visual information (Horn, 1999; Pettersson, 1998; Schriver, 1997; Simlinger, 2007; Zull, 2002). VIs in this study were visual elements used for assisting in memorizing CCs or SRs, e.g., graphics, pictures, colors, and diagrams.

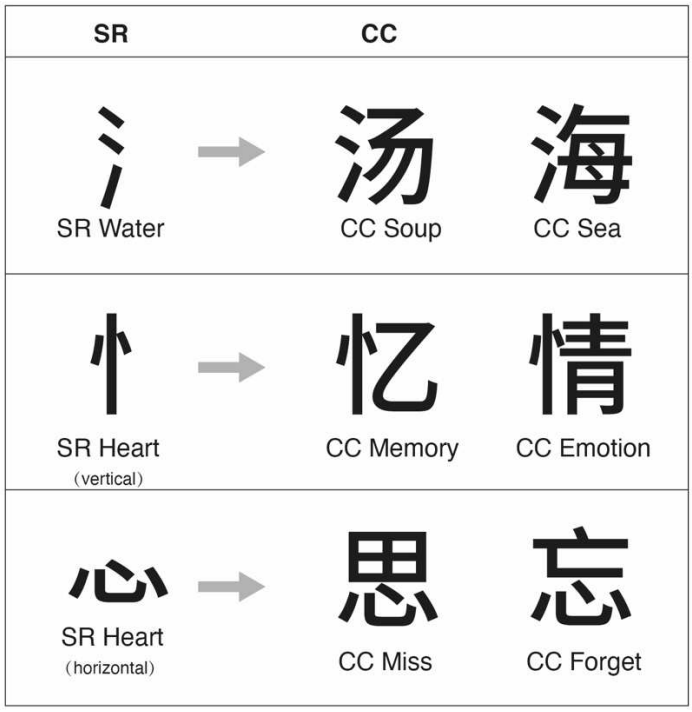

Figure 1. Examples of SRs and CCs.

Cognitive theories, generally used in the fields of psychology and education, build a firm foundation for instructional design (Lonsdale & Lonsdale, 2019; Pettersson, 2014). Cognitive theories about effective VIs for better memory were reviewed.

Dual coding theory (Clark & Paivio, 1991; Paivio, 1986) proposes that both visual coding and verbal coding are independent cognitive systems for processing information in the human brain. When visual and verbal codes are activated together, people have a better memory than activating only one of them (Mayer, 1993; Moreno & Mayer, 2000). Information presented with pictures and texts means readers can decode the same information twice (Winn, 1993). Additionally, pictures are important for facilitating long-term memory (Clark & Paivio, 1991; Paivio, 1971). Based on the dual coding theory, a 'picture superiority effect' refers to the phenomenon that human memory is more sensitive to visual information than verbal information (Curran & Doyle, 2011; Defeyter et al., 2009; Paivio, 1986; Pettersson, 2014).

Cognitive load theory (Chandler & Sweller, 1991) suggests that effective VIs benefit memory by directing cognitive information. If instructions require learners to split their attention among various sources of information, they are less effective. 'Split-attention effect' refers to the phenomenon whereby learners are forced to split their attention when explanatory text is separate from the related illustrations. The received information may be meaningless when it is presented far away from its related text content (Ayres & Sweller, 2005; Chandler & Sweller, 1991, 1992; Ward & Sweller, 1990). The following principles are suggested to avoid imposing an external cognitive load. First, effective VIs should integrate multiple physical sources of information (Chandler & Sweller, 1991). Rune Pettersson (2010) also indicates that a meaningful integrated whole work (one that includes illustrations, colors, symbols, and texts as a whole) is more effective than several individual elements. Second, effective VIs should be self-explanatory (Chandler & Sweller, 1991). Third, effective VIs should not have redundant information (Chandler & Sweller, 1991). The above theories and principles were used in this study to guide the development of prototypes.

Different design elements of VIs have different functions. For example, illustrations are generally used to enhance the understanding of corresponding texts and make subjects more attractive (Heller & Chwast, 2008). Illustrations are commonly used as VIs in textbooks for enhancing memory (Gombrich, 1990; Peeck, 1993). More specifically, illustrations are widely used for resemblance (Gombrich, 1990; Hall, 2011; Horn, 1999; Male, 2017; Szlichcinski, 1980) and memory enhancement (Peeck, 1993; Defeyter et al., 2009; Curran & Doyle, 2011). Color has been recognized as an effective tool to motivate learners in their educational experiences (Wichmann et al., 2002). Color also can be used to enhance memory, increase attention, and boost clarity and distinction (Olurinola & Tayo, 2015). Color coding has been recommended as an effective tool to emphasize elements, organize information, improve attention, and enhance memory in VIs (Bradshaw, 2003; Peck & Hannafin, 1988; Pettersson, 2015; Samara, 2007).

In previous studies with a similar focus, some design elements were used to enhance language learning. For instance, pictures are suggested as an effective tool for learning English (Akbari, 2008; Louie & Sierschynski, 2015), Arabic (Aldalalah et al., 2010), and Spanish (Snyder & Colón, 1988). Color marks are recommended to increase the effectiveness of learning Russian (Birzer & Zinsmeister, 2016). Moreover, pictures and diagrams bring a positive impact on learning English root words (Gill, 2007), which is similar to Chinese SRs to some extent.

When it comes to memorizing CCs and SRs, previous studies investigated the effectiveness of pictorial VIs. Kuo and Hooper (2004) examined pictorial VIs for memorizing the meanings of CCs.

Wang (2014) investigated the effectiveness of animation in memorizing the meanings of CCs. Lai and Newby (2012) compared the effectiveness of static pictures, step-by-step pictures, and animated pictures for the memorizing meanings of SRs. Wang (2014) reported that animations worked significantly better than textual-only instructions. Lai and Newby (2012) demonstrated that pictures had significant advantages in short-term memory but not in long-term memory. However, Kuo and Hooper (2004) reported that the dual-coding group (pictures and texts) did not show significantly better accuracy than the single-coding group (either pictures or texts) in both short-term and long-term memory tests. Kuo and Hooper's (2004) views differ from those of the above studies. Kuo and Hooper (2004) did not provide actual pictures tested in their study. Therefore, the quality of the pictures was not given the needed focus in their study.

Accordingly, using pictures in VIs to enhance language learning is popular. However, the effectiveness of pictures for memorizing CCs and SRs is still debatable. This might be because the quality of the pictures was not given the needed focus in some studies. Some studies described the testing pictures as meaning representations without providing actual pictures (e.g., Kuo & Hooper, 2004). Some studies showed examples of testing pictures or animations (e.g., Lai & Newby, 2012). However, the tested pictures are relatively small, concrete, and detailed, which might have influenced the effectiveness of the VIs. This suggests that the quality and style of pictures were not important considerations in the previous studies, which might have influenced the effectiveness of the VIs.

This study used mixed qualitative and quantitative methods, including an interview, a visual content audit, a quasi-experimental study (Study A), a usability test (Study B), and an experimental study (Study C). The interview was conducted with four teachers and ten students. The 14 participants were recruited in 'Language for All' at the University of Leeds and Confucius Institute[1]. Sixty-five participants took part in the three studies, and all participants took part only once. All participants were recruited via email at Leeds University.

2. Preliminary study

The purpose of the preliminary study was to determine if real-life situations are in line with the literature review and narrow the range of research. A semi-structured interview was conducted to study the challenges of memorizing CCs by beginners and the use of VIs for memorizing CCs. A visual content audit of existing learning materials was conducted to investigate what ideas are in the existing designs.

[1] The Confucius Institute is an educational organization affiliated with the Chinese government (Confucius Institute, 2022). Confucius Institutes provide Chinese courses aimed at adult learners who are interested in learning Chinese in their spare time.

2.1. Interview

2.1.1. Method

A total of four Chinese language teachers (T1 to T4) and ten students (S1 to S10) participated in the interview. Four teachers and seven students (S1 to S5 and S9 to S10) were interviewed using a one-to-one semi-structured interview. Students S6, S7, and S8 were interviewed using the group interview method after they just finished the HSK test[2]. Table 1 shows the participants' teaching or learning experiences of Chinese. All participants were asked two questions. Question 1: What are the challenges of memorizing CCs? Question 2: How do you think of using VIs for memorizing CCs? Question 1, firstly, aimed to explore whether the memorization of SRs is the challenge of memorizing CCs. Secondly, it aimed to explore the importance of VIs for memorizing SRs. Question 2 aimed to investigate different opinions about VIs for enhancing memorizing CCs.

Teachers	Experiences with teaching Chinese
T1 - T3	They taught non-specialist beginners' course when the interview was conducted.
T4	T4 had taught specialist beginners' course in the past.
Students	**Experiences with learning Chinese**
S1 - S5	They were non-specialist beginners, as they only took five weeks courses (90 minutes per week).
S6 - S8	They were elementary level non-specialist learners, i.e., one year learning experience.
S9 - S10	They were advanced level specialist learners, i.e., three years learning experience.
Note: S = Student; T = Teacher **Specialist beginners**: the Chinese language beginners who are taking Chinese language degrees. **Non-specialist beginners**: the Chinese language beginners who are not taking Chinese language degrees.	

Table 1. Experiences with teaching or learning Chinese of the participants in the interview.

2.1.2. Findings

For memorizing CCs, participants identified two challenges (responding to question 1). First, students do not use Chinese SRs well when memorizing CCs. The first challenge was supported by T1, T2, T3, S3, S4, S8, and S9 (Table 2 shows evidence). The other teacher and students talked about other challenges, like negative emotions and the difficulties of writing CCs, which were not related to this study and were not listed in Table 2. The findings of the first challenge confirmed the necessity of memorizing SRs. Second, memorizing CCs relies on self-learning because the class time for CCs is always limited. Table 2 lists the evidence from the interview to support the two challenges. The interview led to a comprehensive understanding of real-life situations for learning and teaching CCs in the UK. Moreover, the findings of the interview supplemented what was lacking in the

[2] HSK test is the international standard test about Chinese language proficiency for non-native Chinese Speakers, which aims to assess their language ability in daily and academic life.

literature review. The effect of memorizing SRs was confirmed by teachers, as this has been stated by many scholars (e.g., Lü et al., 2015; Zhang et al., 2016; Nguyen et al., 2017). However, in a real situation, teachers stated that students, especially beginners, did not use SRs well. This meant the benefits of SRs for memorizing CCs had not been fully used. This implied VIs for memorizing SRs needed more research. The second challenge that learners memorizing CCs relies on self-learning showed the need to find effective VIs.

Regarding question 2, participants held different opinions about the effectiveness of VIs for enhancing memorizing CCs (see Table 2). Six participants agreed on the benefits of VIs for assisting in memorizing CCs, which aligned with some previous research (e.g., Lai and Newby, 2012). Five participants held a neutral opinion, and three participants thought that VIs should not be widely promoted. The reasons why participants held a negative opinion are as follows. First, participant T4 indicated that it was not realistic to make all CCs a specific picture, as there was a huge number of CCs. Second, participant S6 stated that rote memorizing could not be replaced by looking at pictures as repetition was still an effective way to memorize CCs. However, the purpose of VIs was to facilitate memorizing CCs rather than replace rote memorizing CCs. These different opinions about VIs showed that more research on VIs for enhancing memorizing CCs is needed.

Question 1: What are the challenges for students in memorizing CCs?
Finding 1. Students do not use Chinese SRs well when memorizing CCs.
Evidence T1 said: "Semantic radicals are supposed to be a strong helper for learning, understanding, and memorising Chinese characters. However, students do not always use it well." T2 said: "'Students are not able to use semantic radicals as building blocks to build Chinese characters." T3 said: "It is always arduous for beginners to understand and to use semantic radicals to memorize Chinese characters." S3 said: "My teacher told us if we know radicals, it will be easy to remember many characters. But, you know, radicals are also difficult to remember." S4 said: "I think I understand the rules of characters, like building blocks. I think, it is called radicals. But remember radicals is also difficult, they are too different from letters, you can't spell it." S8 said: "There are too many characters, it will be good if you know the rules of building characters, like radicals. But I can't remember all of them." S9 said: "I don't think it is challenging to learn Chinese characters when you know the rules of Chinese semantic radicals. But I understand that the knowledge of semantic radicals is difficult for beginners."
Finding 2. Memorizing CCs relies on self-learning because the class time for CCs is always limited.
Evidence from teachers T1 said: "We prefer to use the majority of class time to practise speaking rather than explaining characters. Generally, we only use about five minutes to learn new characters." T2 said: "Communicating is always the primary goal for beginners, and it is effective to practice in class. Chinese characters could be practiced after class." T3 said: "They can practice characters on their worksheets after class."
Question 2: How do you think of using Visual Instructions (VIs) for enhancing memorizing CCs?
Finding1. Positive opinions about using VIs.
Evidence T1, T3, S1, S4, S8 and S9 considered VIs as an effective method for enhancing memorizing CCs. For example, T3 said, "I'm more than happy to suggest my students use pictures if they are effective." T1 said, "I always try to find some photos to facilitate my teaching." S1, S4 and S9 suggested the book Chineasy (Hsueh, 2014; Hsueh, 2016), for example, S9 said, "I find pictures and stories are useful for me. Chineasy is fascinating." S3 said, "I like teachers providing some pictures when teaching characters because pictures are easy to understand."
Finding 2. Neutral or dubious opinions about using VIs.
Evidence T2, S2, S5, S7 and S10 held neutral or dubious opinions. For example, S2 said, "I don't know whether pictures are useful or not for adults. Generally, it is more attractive for children." T2 stated "It is not easy to find useful and good-quality illustrations all the time. Most of the pictorial instructions are drawn for Pictogram characters. However, Pictogram characters are a tiny part of Chinese characters."
Finding 3. Negative opinions about using VIs.
Evidence T4, S3 and S6 took negative opinions. For example, T4 said, "I don't think it is possible to draw pictures for all characters. Some characters are too far away from its originally pictorial meaning." S6 stated that "I learnt characters by a lot of repetition, and it works, I don't think pictures can make me remember hundreds of characters."
Note: CC = Chinese Character; S = Student; SR = Semantic Radical; T = Teacher

Table 2. Results of the interview.

2.2. Visual content audit

2.2.1 Method

The visual content audit aimed to investigate what ideas in the existing designs informed this research. The audit explored 30 materials (Table 3). Due to the limitations of VIs for memorizing Chinese SRs by non-specialist beginners, the scope of the visual content audit was expanded as follows.

Choosing existing VIs was not restricted to:

1) VIs for memorizing CCs or SRs. The scope covered SRs, CCs, words, and pronunciations.
2) Simplified CCs, which are used in mainland China. Traditional CCs that are used in Taiwan, Hong Kong, Japan (kanji), and Korea (hanja) were also included in this survey.
3) L2 beginners. VIs for L1 beginners, i.e., elementary school students, were also included.
4) Non-specialist beginners. VIs for specialist beginners were also included.
5) Paper-based VIs. VIs on websites and mobile applications were also included.

Table 3 lists the 30 materials and related forms of VIs, i.e., instructional colors, diagrams, and illustrations. In the materials, instructional colors were the colors used for instructions rather than decorations. Diagrams were instructions that had lines and shapes for showing relationships. For example, a diagram can show the relationship between CCs and SRs. Illustrations were drawings for memorizing Chinese. Illustrations had different styles, e.g., realistic styles and abstract styles. Realistic style illustrations were identified by the depiction of real life. Abstract style illustrations were identified by the depiction with simplified details and abstract shapes. The audit showed that 25 materials had illustrations, six materials had instructional colors, and seven materials had diagrams. Illustrations were the main form of VIs for memorizing CCs or SRs in the existing materials, 12 were realistic style, and 13 were abstract style. None of the two styles was chosen by most of the existing materials.

To sum up, the interview led to a comprehensive understanding of real-life situations for learning and teaching CCs in the UK. Moreover, the findings of the interview supplemented what was lacking in the literature review. The literature review showed that the knowledge of SRs facilitates memorizing CCs by beginners (Lü et al., 2015; Nguyen et al., 2017; Su & Young-Suk, 2014; Zhang et al., 2016). The findings of the interview showed that students do not use SRs well when memorizing CCs. The findings of the interview confirmed the necessity of this study from real-life situations. The visual content audit explored existing designs that use VIs for enhancing CCs or SRs. Moreover, it provided materials for Study A (Section 3).

Cases	References	Instructional color	Diagrams	Illustrations	Styles of illustrations
StNo.1	(Peng, 2012)	-	-	✓	Realistic
No.2	(Rowley, 1992)	-	-	✓	Abstract
No.3	(University of Tokyo Kanji Research Group, 2015)	-	-	✓	Abstract
No.4	(X. Zhang, 2014)	-	-	✓	Realistic
No.5	(Matthews & Matthews, 2007)	-	-	✓	Realistic
No.6	(Hirzel et al., 2007)	-	-	✓	Abstract
No.7	(Niemann, 2008)	-	-	✓	Realistic
No.8	(Li & Song, 2008)	-	-	✓	Abstract
No.9	(Banno et al., 2009)	-	-	✓	Abstract
No.10	(Peter, 2013)	✓		-	
No.11	(Taiwan Knowledge Bank Co. Ltd, 2012)	-	-	✓	Abstract
No.12	(Rowley, 1992)	✓	✓	✓	Abstract
No.13	(Ninchanese Team, 2013)	✓	✓	-	
No.14	(Ferguson, 2013)	✓	✓	✓	Realistic
No.15	(Digmandarin Team, 2013)	-	✓	-	
No.16	(Z. Wang & ChineseSkill Team, 2014)	-	-	✓	Realistic
No.17	(Dave, 2014)	✓	✓	-	
No.18	(Monkimun Team, 2014)	-	-	✓	Realistic
No.19	(Greenwood, 2014)	-	-	✓	Abstract
No.20	(Hsueh, 2014)	-	-	✓	Abstract
No.21	(Lohove, 2015)	✓	✓	✓	Realistic
No.22	(Knabe, 2016)	-	✓	-	
No.23	(Hsueh, 2016)	-	-	✓	Abstract
No.24	(Stout & Hakone, 2016)	-	-	✓	Realistic
No.25	(XiaoXiang Hanzi, 2016)	-	-	✓	Realistic
No.26	(Chang, 2016)	-	-	✓	Realistic
No.27	(XiaoXiang Hanzi, 2017a)	-	-	✓	Abstract
No.28	(XiaoXiang Hanzi, 2017b)	-	-	✓	Abstract
No.29	(bunkyosha, 2017)	-	-	✓	Realistic
No.30	(Gakken, 2018)	-	-	✓	Abstract
Sum		**6**	**7**	**25**	**Realistic style: 12** **Abstract style: 13**
Note		✓ =The material has the form of VIs. - =The material dose not has the form of VIs.			

Table 3. The 30 materials and related VIs that explored in the visual content audit.

3. Study A: Quasi-experimental study

A quasi-experimental study was conducted to explore participants' opinions about existing materials, aiming to explore what kind of VIs enhance the memorizing of SRs and how they enhance such memorizing. Study A included a memorize-and-test task and a ranking task. The ranking was a question format and a measurement to explore the participants' opinions (Oldendick, 2008). The forced ranking was an effective strategy to avoid some VIs that were rated at the same level, and then it could show an explicit answer. The quasi-experimental study was a within-subjects study where the same participants tested all materials.

3.1. Method

3.1.1. Participants

Thirty participants (mean age 29) were recruited; 21 were female, and nine were male. The criterion for the recruitment was no prior knowledge of the Chinese language. All participants lived or studied in the UK and came from 12 nationalities.

3.1.2. Materials

The 30 materials (refer to Table 3) explored in the visual content audit (Section 2.2) were used as materials in Study A. In the memorize-and-test task, six of the 30 materials (No. 2, 5, 10, 13, 20, and 21) were selected and used. The selected materials needed to meet four criteria. Table 4 shows the criteria for selecting six from the 30 materials.

Initially, this study aimed to explore VIs for enhancing memorizing SRs rather than CCs. Therefore, the first criterion was materials that have VIs for instructing SRs rather than CCs. Secondly, this study aimed to explore VIs for enhancing memorizing individual SRs one by one rather than memorizing a collection of SRs at the same time. Consequently, the second criterion was materials that have VIs for instructing one SR per page rather than a collection of SRs. Thirdly, the complete knowledge of SRs includes the meanings, shapes, and positions of SRs. This study aimed to explore VIs for memorizing the complete knowledge of SRs rather than part of them. For example, material No.6 does not show the position information of SRs. Therefore, the third criterion was materials that have VIs for instructing the complete knowledge of SRs. Lastly, the fourth criterion was materials that do not highlight phonetic information. Phonetic and other information about CCs was not considered because this study only focused on memorizing SRs. Six materials meet the four criteria. They were used as materials for the memorize-and-test task in Study A. Moreover, the six materials were used as a design reference for developing prototypes in Study B and Study C.

Criteria	Materials														
Criterion 1 Materials that have VIs for instructing SRs rather than CCs.	1	**2**	3	4	**5**	**6**	7	**8**	9	**10**	11	12	**13**	**14**	**15**
	✗		✗	✗			✗		✗		✗	✗			
	16	**17**	18	19	**20**	**21**	**22**	23	24	25	26	27	28	29	30
	✗		✗	✗				✗	✗	✗	✗	✗	✗	✗	✗
Criterion 2 Materials that have VIs for instructing one SR per page rather than a collection of SRs.		**2**			**5**	**6**		8		**10**			**13**		**15**
								✗							
		17			**20**	**21**	22								
							✗								
Criterion 3 Materials that have VIs for instructing the complete knowledge of SRs.		**2**			**5**	6				**10**			**13**		15
						✗									✗
		17			**20**	**21**									
Criterion 4 Materials that do not highlight phonetic information.		**2**			**5**					**10**			**13**		
		17			**20**	**21**									
		✗													

Note:

Meet the criterion

✗ Do not meet the criterion

1-30. The 30 materials refer to Table 3.

The selected materials need to meet all the criteria. Therefore, materials that do not meet the previous criteria are not listed in latter columns. For example, material No. 1 does not meet the first criterion, so it is not listed in the latter columns.

Table 4. The selection of the six materials used in the memorize-and-test task from the 30 materials.

The materials used in the memorize-and-test task had SRs Heart (horizontal), Fire (vertical), Water, Food, Grass, and Hand (vertical). The SRs were recommended by Chinese language teachers for two reasons. First, the six SRs are beginner-level SRs and common SRs, which are listed in the textbook Discover China[3] (Anqi et al., 2020). Second, the six SRs are high combinability SRs, which means the SRs compose many CCs. For example, SR Water composes CC Sea, CC Soup, CC Oil and CC Float, and so on. Figure 2 shows similar visual examples to the six materials designed by the researcher due to copyright issues. SR Mountain (horizontal) (山) and related CCs were used as examples. The six materials introduced SRs with different VIs. Material A, Material B, and Material E introduced SRs with illustrations. Material C introduced SR with instructional colors. Material D introduced SRs with instructional colors and diagrams. Material F introduced SRs with illustrations, instructional colors, and diagrams.

[3] The textbook Discover China (Anqi et al., 2010) was designed for non-specialist adult learners. Discover China (Anqi et al., 2010) shows 110 common radicals, including 92 SRs. This book was used in some Universities' electives of the Chinese language, e.g., 'Language for All' at the University of Leeds, and some Confucius Institutes, e.g., Lancaster University Confucius Institute.

In the memorize-and-test task, participants had a memory test, including Meaning Recall Questions (MRQs), Radical Recall Questions (RRQs), and Position Recall Questions (PRQs). MRQs and RRQs were used in previous studies (e.g., Wang, 2014; Chen et al., 2013; Lai & Newby, 2012). Position information of SRs is important knowledge of SRs (Shen & Ke, 2007; Xu et al., 2014). Therefore, PRQs were asked to examine how participants remembered the position information of SRs in this study. Figure 2 also shows memory test sheets, including an MRQ sheet, an RRQ sheet, and a PRQ sheet.

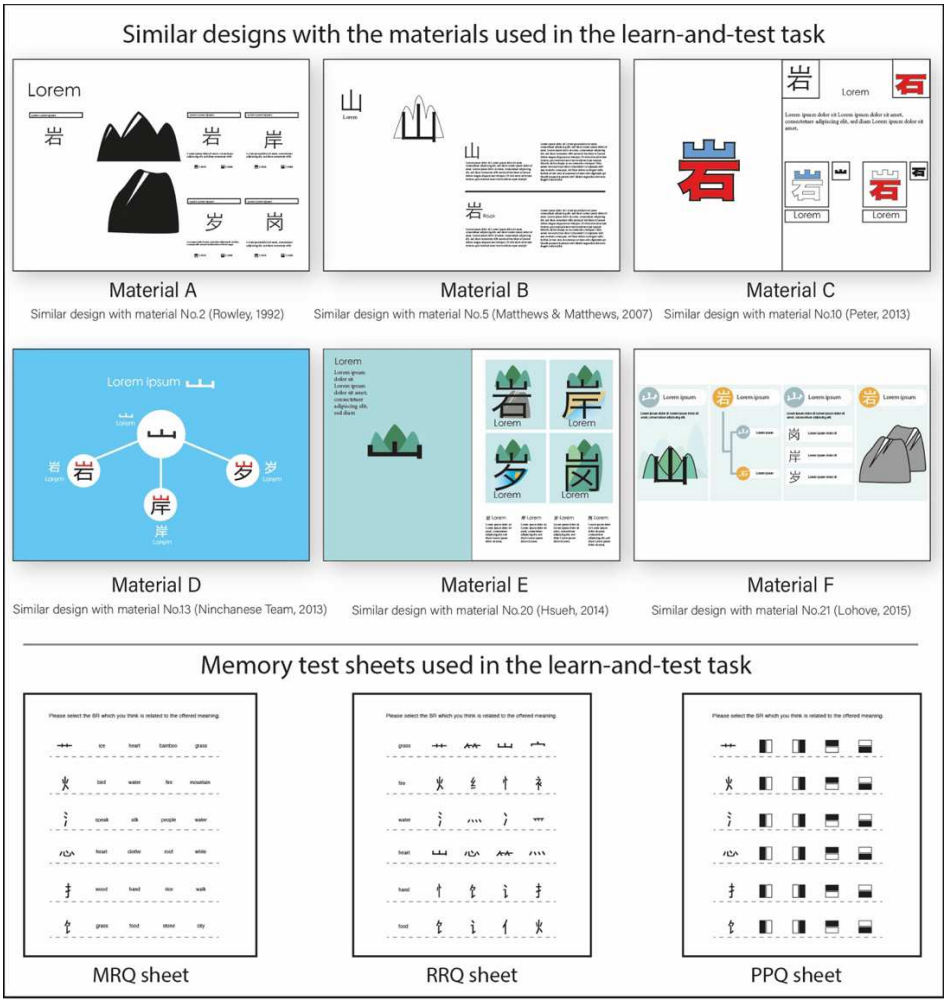

Figure 2. Similar designs to the materials used in the memorize-and-test task and memory test sheets used in the memorize-and-test task.

In the ranking task, all 30 materials (see Table 3) were used. In the 30 materials, illustrations, instructional colors, and diagrams had different visual variables. For example, illustrations were drawn in different groups of colors, i.e., chromatic colors, monochromatic colors, and achromatic colors. Figure 3 shows all the visual variables of illustrations (yellow part), instructional colors (green part), and diagrams (red part) in the 30 materials, including how the visual variables were identified. For example, the integrated-and-imitation combination of SRs and illustrations described that the illustrations integrated with CCs or SRs, the illustrations imitated the shapes of CCs or SRs, and the

illustrations also visualized the meanings of CCs or SRs. SR Mountain (horizontal) (山), CCs Rock (*岩*), High (*嵩*), Coast (*岸*), and hillock (*岗*) were used as examples in Figure 3.

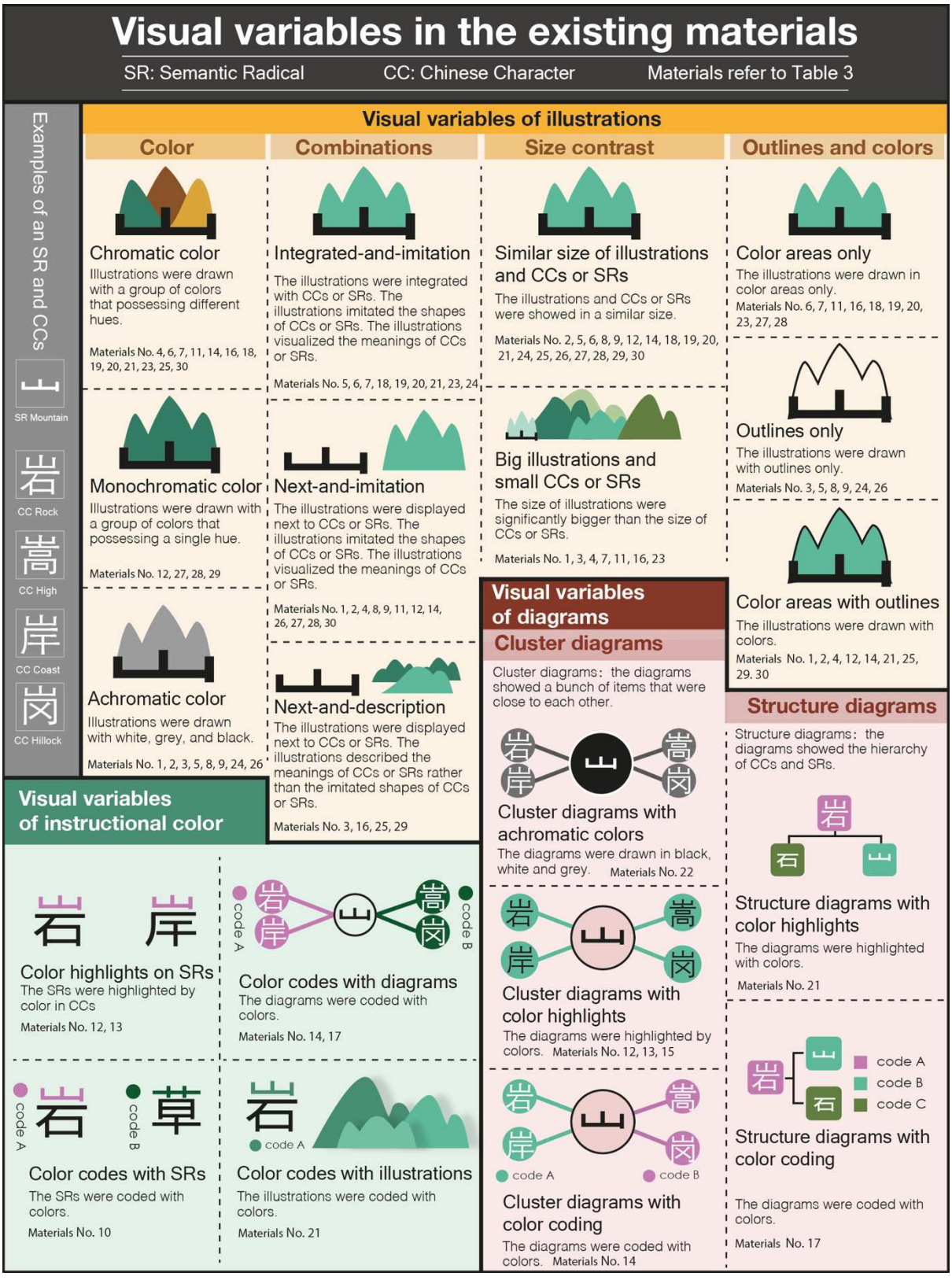

Figure 3. Visual variables in the existing materials.

3.1.3. Procedure

Participants first had a memorize-and-test task and then a ranking task. In the memorize-and-test task, all participants were given six materials (refer to Figure 2) in random order, and they were asked to read and memorize the SRs within 10 minutes. Then, they were asked to finish a set of memory tests, including six RRQs, six MRQs, and six PRQs (refer to Figure 2). The test was paper administered.

In the ranking task, participants were given six ranking tasks (Figure 4). Each task was shown with two to five sheets (refer to the example of the ranking task 2 in Figure 4), and each sheet corresponded to a variable. Participants were asked to rank the sheets from easy-to-memorize to hard-to-memorize. Participants were not allowed to rank any sheet at the same level. The 30 materials were used as visual examples in the ranking task. For example, the participants were given three sheets in random order in ranking task 2. After the participants moved the sheets into their order from the easiest to the hardest, the researcher turned over each page to see the order of A, B, and C (see Figure 4). The researcher wrote down the order, e.g., BAC. This process was repeated for the six ranking tasks.

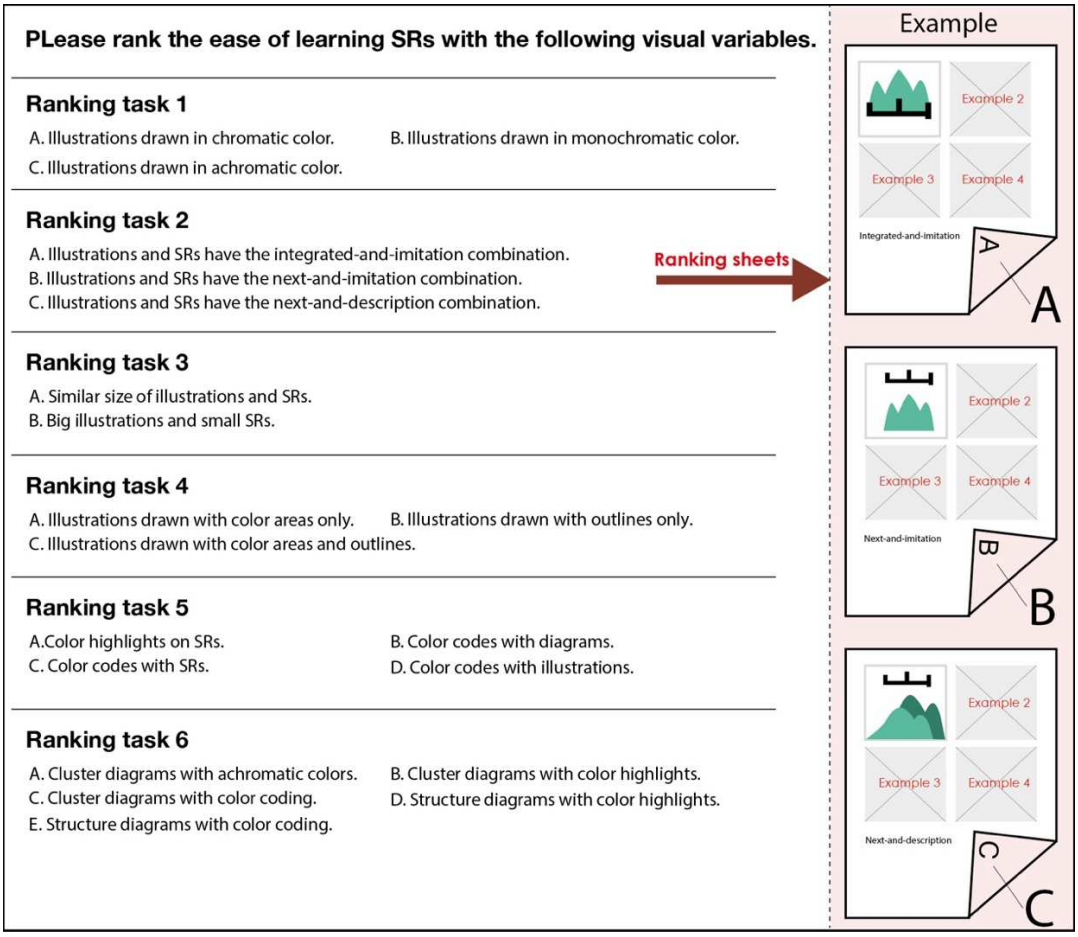

Figure 4. Ranking tasks and the example of ranking sheets used in Study A.

3.2. Results

Figure 5 shows the results of Study A. The results of the memorize-and-test task showed that materials that had illustrations (Materials A, B, E, and F) had a higher percent accuracy in RRQs than those that did not have illustrations (Materials C and D): A (93%) = E (93%) > B (87%) > F (73%) > D (53%) > C (37%). Similarly, materials that had illustrations had higher accuracy in MRQs than those that had no illustrations: A (90%) = B (90%) > E (87%) > F (70%) > D (63%) > C (53%). Unlike RRQs and MRQs, the results did not show an obvious trend in the accuracy of PRQs: C (87%) > A (83%) > F (67%) > D (60%) = E (60%) > B (53%).

Figure 5. The results of Study A.

The results of the ranking task showed that the participants had an obvious preference for some variables over others in terms of ease of memorizing SRs. For example, 60% of the participants chose the integrated-and-imitation combination, 33% chose the next-and-imitation combination, and 7% chose the next-and-description combination. Apart from diagrams, the other highest of participants' choices (highlighted in orange in Figure 5) was used for developing prototypes, e.g., illustrations were drawn in chromatic color. Regarding diagrams, more than 60% of participants considered that cluster diagrams were easier to read and memorize than structure diagrams. Diagrams were more often used to introduce a group of CCs rather than a single CC or SR in the existing materials. This study aimed to develop VIs for enhancing memorizing individual SRs rather than presenting a collection of SRs. Therefore, diagrams were not considered in developing the prototypes. Consequently, the participants chose illustrations drawn with chromatic color without outlines as easy-to-memorize illustrations for memorizing SRs. Regarding the combination of illustrations and SRs, it was suggested by participants that a similar size of illustrations, which were integrated with SRs and were drawn to imitate shapes of meanings, were easy to memorize SRs. In other words, the illustrations in VIs for memorizing SRs are supposed to be concise and clear for presenting information. When introducing SRs with instructional color, memorizing SRs with color coding was chosen as the effective VI. The findings of Study A provided valuable information for developing prototypes for memorizing SRs in Study B (Section 4).

4. Study B: Usability test

Study B aimed to produce, refine, and test design prototypes. A usability test was conducted to develop prototypes and examine the effectiveness of the prototypes. The usability test was a within-subjects study that the same participants tested all VIs. Five participants were recruited for the usability test. It is suggested that conducting a usability test with no more than five users is sufficient to identify design issues (Nielsen, 2000).

4.1. Method

4.1.1. Participants.

Five participants (mean age 28) were recruited; three were female, and two were male. The five participants did not participate in Study A. All participants had no prior knowledge of the Chinese language. All participants lived or studied in the UK and came from three nationalities.

4.1.2. Materials

Fiv*e* prototypes (U1, U2, U3, U4, and U5) were developed and tested in Study B. Figure 6 shows and describes the five prototypes. Prototypes U2, U4, and U5 have color coding as VIs, therefore, the color coding is highlighted in Figure 6.

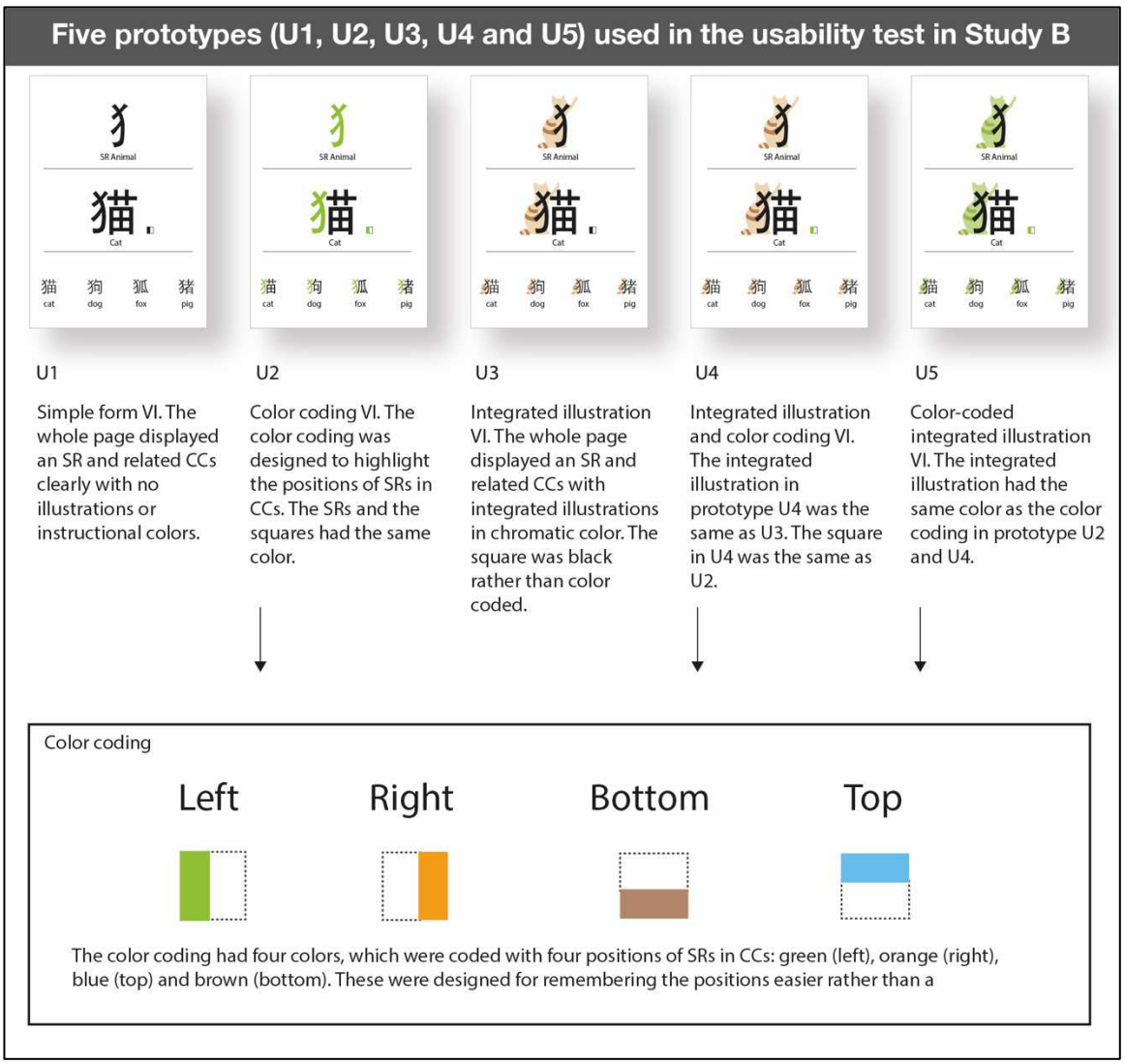

Figure 6. Five prototypes (U1, U2, U3, U4, and U5) were used in the usability test.

Twenty SRs were designed with U1, U2, U3, U4, and U5. The 20 SRs were divided into five groups (four SRs per prototype). Each group of SRs had similar difficulties because the total number of strokes in each group was identical. Table 5 shows the 20 SRs which were used in Study B. Considering the difficulties for beginners and the length of the learning time, 20 SRs were selected from the list of common SRs in the textbook Discover China (Anqi et al., 2020). First, for relatively easy-to-memorize, SRs with two to four strokes were selected. Second, for testing the effectiveness of the color coding, SRs of the four positions were selected. Fifty common SRs meet the two criteria, including eight SRs with two strokes, 22 SRs with three strokes, and seven SRs with four strokes. Table 5 shows that each group has one two-stroke SR, two three-stroke SRs, and one four-stroke SR.

	SR1	SR2	SR3	SR4
Group 1	亻	口	宀	贝
Strokes	2	3	3	4
Group 2	冂	子	忄	心
Strokes	2	3	3	4
Group 3	冫	艹	纟	灬
Strokes	2	3	3	4
Group 4	刂	犭	土	日
Strokes	2	3	3	4
Group 5	阝	巾	饣	牛
Strokes	2	3	3	4

Table 5. The five groups of the 20 SRs used in Study B.

By exploring the origins of the 50 common SRs (Anqi et al.,2020) in Xinhua Dictionary[4] (Institute of Linguistics, The Chinese Academy of Social Sciences, 2011), the results showed the 50 SRs originated from Pictograms [Xiang Xing] and Ideograms [Zhi Shi] [5], which means the SRs keep their pictorial meanings and all are easy to use illustrations. Therefore, the number of strokes and positions of SRs were the reasons for selecting the 20 SRs from the 50 SRs. All the 50 SRs are easy-to-use illustrations.

4.1.3. Procedure

The participants were asked to do a memorize-and-test task and an after-test survey. First, the participants were informed of the process of the tasks and information about color coding before the memorizing task. Then, they were asked to memorize 20 SRs with the materials from U1, U2, U3, U4, and U5. After the memorizing task, they were given a paper-administered test, including 20 RRQs, 20 MRQs, and 20 PRQs. The 60 questions were asked in random order. The accuracy and time for memorizing were collected. The time for memorizing was recorded with a stopwatch. After the memorize-and-test task, participants were asked their opinions about the memorizing experience and suggestions about the five prototypes.

[4] Xinhua Dictionary is a Chinese language dictionary published by the Commercial Press. In 2016, Guinness World Records confirmed that Xinhua Dictionary is the 'Most popular dictionary' in the world.

[5] Pictograms [Xiang Xing] and Ideograms [Zhi Shi] are two categories of CCs. Pictograms [Xiang Xing] means a CC is a figure that represents an object. Ideograms [Zhi Shi] means a CC is a figure that suggests the meaning in an abstract way (Wieger, 1965; Norman, 1988).

4.2. Results

Memorizing SRs with prototypes U1 (45%) and U2 (40%) showed lower average percent accuracy than memorizing SRs with U3 (70%), U4 (70%), and U5 (85%) in RRQs. Similarly, memorizing SRs with prototypes U1 (50%) and U2 (45%) showed lower accuracy than memorizing SRs with U3 (65%), U4 (75%), and U5 (85%) in MRQs. However, the results of the PRQs showed a different trend: U2 (75%), U3 (75%), U4 (60%), and U5 (80%) had higher accuracy than U1 (45%). The average memorizing time from U1 to U3 showed a decrease in seconds from 110s to 59s. Then, the average memorizing time showed a slight increase from U3 (59s) to U4 (67s). Memorizing SRs with U5 (63s) showed four seconds less. Figure 7 shows the results of the memorize-and-test task in Study B.

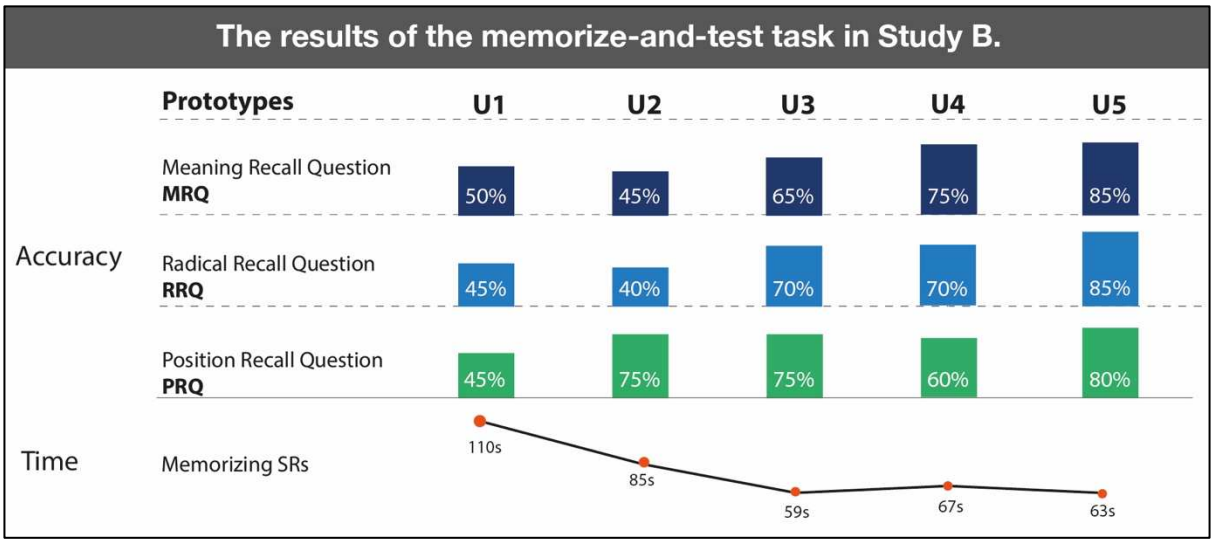

Figure 7. The results of the memorize-and-test task in Study B.

The after-test survey showed three findings. First, the prototypes lacked a focus on SRs. They indicated that the middle part of the page drew more attention than other parts. The middle part was a CC in big size, which was not the most important information for the memorizing purpose of this study. Second, three participants pointed out that the squares for highlighting SR positions were too small. They indicated that the small squares were easy to be ignored, but they held positive opinions about the effect of squares. Third, three participants stated that the order and time of memorizing SRs with different prototypes might influence the memory test.

Therefore, SRs in the prototypes need to be given more attention, and the size of squares needed to be adjusted. The order of memorizing SRs of different prototypes needs to be randomized. The memorizing time with different prototypes needs to be set the same.

The results of Study B showed that participants had higher accuracy for answering RRQs and MRQs when memorizing SRs with illustrations (U3, U4, and U5) than those without illustrations (U1 and U2). Participants had higher accuracy for answering PRQs when memorizing SRs with illustrations and color coding (U2, U3, U4, and U5) than without those elements (U1). The prototypes for

memorizing SRs needed to be adjusted. The adjusted prototypes were examined in Study C (Section 5).

5. Study C: Experimental study

Study C aimed to examine the effect of the integrated illustrations and the color coding for memorizing SRs. The experimental study was a within-subjects study, including a memorizing task, an Immediate Test (IT), and a Delayed Test (DT).

5.1. Methods

5.1.1. Participants

Thirty participants took part in the experimental study (mean age 22, 16 females, and 14 males). All the participants had no prior knowledge of the Chinese language. All participants lived or studied in the UK and came from 13 nationalities.

5.1.2. Materials

Prototypes U1, U2, U3, U4, and U5 were adjusted to E1, E2, E3, E4, and E5 respectively. Five adjustments were made to the prototypes: layout, proportions of SRs and CCs, color contrast of the background, illustrations, and the size of squares. Taking prototypes U5 and E5 as examples, Figure 8 illustrates the five adjustments. Twenty SRs were designed with E1, E2, E3, E4, and E5. The 20 SRs were the same as the 20 SRs used in Study B (refer to Table 4 in Section 4.1.2). The 20 SRs were divided into five groups (four SRs per prototype). Figure 9 shows the 20 pages of materials (E1, E2, E3, E4, and E5) used in the experimental study.

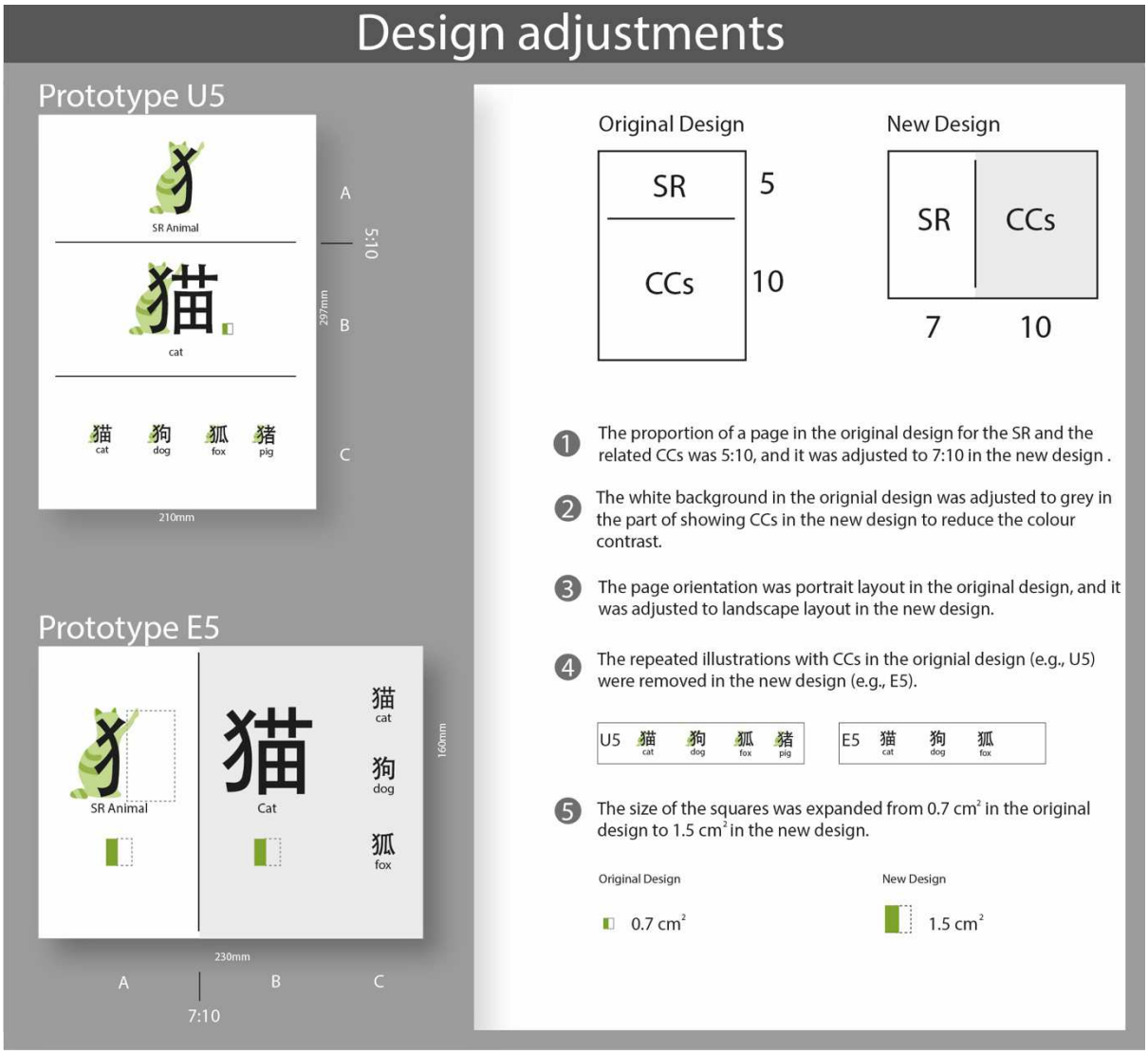

Figure 8. Design adjustments of prototypes in Study C.

Figure 9. Five design concepts used as materials in the experimental study in Study C.

5.1.3. Procedure

The experimental study included a memorizing task, an IT, and a DT. In previous studies with a similar focus, IT and DT were used to test the accuracy of memorization of CCs. For example, Kuo and Hooper (2004) used IT and DT (after seven days) to test participants who had no prior knowledge of CCs. Xu et al. (2013) used IT and DT (after 28 days) to test participants who had prior knowledge of CCs. Therefore, Study C used IT and DT (after seven days) to test participants who had no prior knowledge of CCs. To make the test more rigorous, the memorizing time was set the same

for all participants. The identical length of memorizing time was achieved by displaying the materials on a tablet. They were presented with Microsoft PowerPoint, with one page per slide. Each slide was set to present for 20 seconds and then go to the next one automatically. The 20 slides of materials were presented in random order. All participants used the same tablet. After the memorizing task, they were asked to do the IT (60 questions: 20 RRQs, 20 MRQs, 20 PRQs). All the questions were asked in random order. This was achieved with the Google Forms survey tool. A DT was conducted after seven days. All the participants were asked not to review any SRs during the seven days. All the participants received a link to the test and were asked to finish it within that specific date. The data of accuracy was collected. After the DT, participants were asked to choose one of the concepts as the easiest VI for memorizing SRs.

5.2. Results

Wilcoxon Signed-Rank test (non-parametric test) was used to compare the average percent accuracy. Figure 10 details the average percent accuracy of each concept and the *p*-values of the Wilcoxon Signed-Rank test for comparison. To remind of the five prototypes, prototype E1 is a simple VI; E2 is color code; E3 is integrated illustrations; E4 is integrated illustrations and color coding; E5 is color-coded integrated illustrations. The results of recalling meanings (MRQs) showed that the accuracy of E3 (94%), E4 (83%), and E5(91%) was significantly greater ($p < 0.05$) than E1(58%) and E2(69%) in IT. The results of DT showed a similar trend to the data of IT (see Figure 10). All the accuracy of DT showed no significant difference ($p > 0.05$) from the accuracy in IT.

The results of recalling shapes (RRQs) showed that the accuracy of E3 (94%), E4 (88%), and E5 (93%) were significantly ($p < 0.05$) greater than E1 (63%) and E2 (76%) in IT. The accuracy of E2 (78%), E3 (83%), E4 (75%), and E5 (85%) was significantly greater ($p < 0.05$) than E1 (54%) in DT. The accuracy of E3 (83%), E4 (75%), and E5 (85%) in DT was significantly lower ($p < 0.05$) than the accuracy of E3 (94%), E4 (88%), and E5 (93%) in IT. Comparing the accuracy of DT with the IT, the accuracy of E1 and E2 showed no significant decrease in the DT (Figure 10).

The results of recalling positions (PRQs) showed that the accuracy of E1 (44%) was significantly lower ($p < 0.05$) than the other four prototypes in IT. The accuracy of E5 (91%) was significantly higher ($p < 0.05$) than the others in IT. The accuracy of E1 (51%) was also significantly lower ($p < 0.05$) than the others in DT. The accuracy of E5 (80%) and E3 (84%) showed no significant difference ($p > 0.05$) in DT. The accuracy of E5 (80%) in DT was significantly lower ($p < 0.05$) than the accuracy of E5 (91%) in IT. The accuracy of E1, E2, E3, and E4 in IT showed no significant difference ($p > 0.05$) from the accuracy in DT (Figure 10).

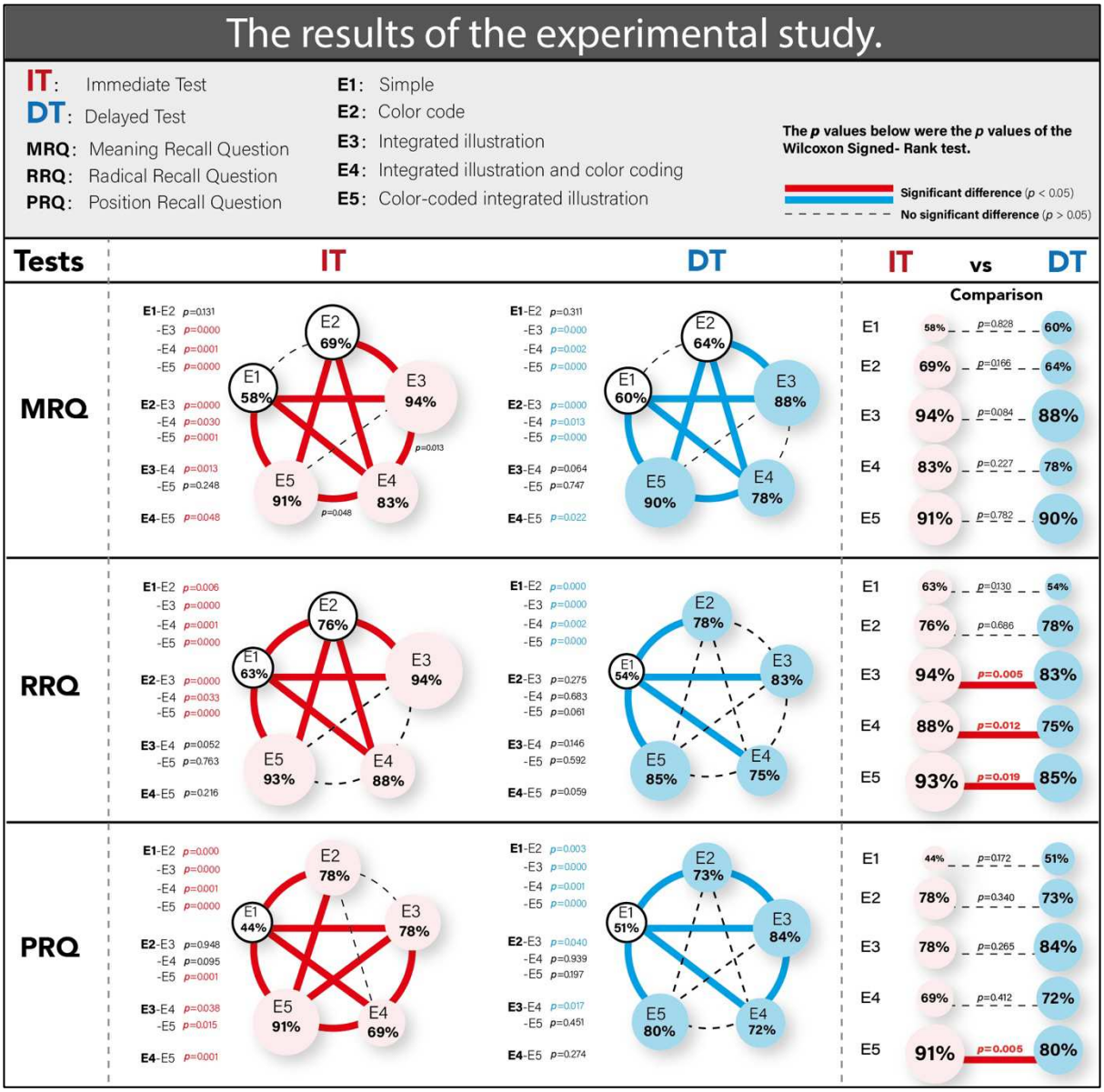

Figure 10. The results of the experimental study in Study C.

After the DT, all the participants were asked to choose one of the five prototypes as the most effective VI for them to memorize SRs. The results showed that none of the participants chose E1 or E2, 23% of the participants chose E3, 27% chose E4, and 50% chose E5.

The results of the participants' spontaneous comments during testing were recorded. The key viewpoints are stated as follows. First, the integrated illustration was an effective VI for memorizing SRs, especially for recalling meanings and shapes. The participants indicated that the SRs displayed with integrated illustrations were easier to memorize. For example, "I've got a good short-term memory, but I'm pretty sure, after one week, only the radicals with pictures will remain in my mind," a participant said. "I feel there is a strong association with visuals, I like the visual stimulation for learning Chinese. I like the way you put the illustrations under the radicals," another participant said.

Second, color coding was an effective learning method for the acquisition of SRs, especially for memorizing positions. For example, “The color coding, you try to link the color and the position, is very helpful for me,” a participant said. Regarding the combinations (E4 and E5) of illustrations and the color coding, 15 participants stated that the color-coded illustrations (E5) were the easiest to remember since they chose E5 as the most effective VI in the survey.

6. Conclusions and discussion

This study investigated the effectiveness of VIs for enhancing memorizing SRs for non-specialist beginners. The preliminary study explored real-life situations and materials for memorizing CCs and SRs. Study A, Study B, and Study C examined the effectiveness of VIs for memorizing SRs. Study A explored the effectiveness of VIs for memorizing SRs in existing materials. Study B developed and tested design prototypes of VIs. Study C examined the effectiveness of the improved design prototypes of VIs. The results of Study C showed that color-coded integrated illustrations were effective VIs for memorizing SRs.

6.1. Major findings in effective VIs for memorizing Chinese SRs

For memorizing Chinese SRs, effective VIs should increase the accuracy of memorization. The color-coded integrated illustrations should be drawn in a concise and understandable way. The results of the visual content audit showed realistic and abstract illustrations are both popular in existing materials. The results of Study A showed participants chose concise and understandable illustrations as easy-to-memorize VIs. The effects of integrated illustrations, color coding, and the combination of them are discussed next by linking them to the literature in order to show how they strengthen previous research and advance knowledge further.

The effect of integrated illustrations: For memorizing SRs, integrated illustrations are a significantly effective VI approach for enhancing memorizing the meanings and shapes of SRs. The results of Study A showed that integrated illustrations in existing materials have the potential effectiveness (high accuracy) for enhancing memorizing the meanings and shapes of SRs. The results of Study C showed that the developed VI with integrated illustrations significantly increased the accuracy of memorizing the meanings, shapes, and positions of SRs. The results are in line with the dual coding theory and the picture superiority effect, which shows that presenting texts with pictures is easier to remember than presenting texts only (Clark & Paivio, 1991; Paivio, 1986; Pettersson, 2014). The finding was in keeping with cognitive load theory, that the integration of multiple information increased the effect of VIs and was easier to remember (Ayres & Sweller, 2005; Chandler & Sweller, 1996; Sadoski & Paivio, 2013).

In Study C, the integrated illustrations showed a significant effect on memorizing the meanings and shapes of SRs in IT and DT. The effect of integrated illustrations for memorizing meanings remained stronger than memorizing shapes in long-term memory (DT). This might be because the associations between the integrated illustrations and the meanings of SRs were stronger than the associations between the illustrations and the shapes of SRs. The effect of the integrated illustrations for memorizing the positions of SRs could remain after seven days. This meant the integrated

illustrations could leave a stronger impression on learners about memorizing the positions of SRs. The new findings of the effect of integrated illustrations on memorizing could be added to the current Information Design literature.

The effect of color coding: In Study A, the results of the ranking task showed that color-coded SRs were thought to be easy to memorize by more than half of the participants (67%). In Study C, the results of IT showed that memorizing SRs with color coding had significantly higher accuracy than those without color coding for answering RRQs and PRQs. The results of DT showed that the effect of color coding could remain (at least seven days).

Although the color coding was designed for highlighting and memorizing the positions of the SRs, the chromatic color highlighted the shapes of SRs. Compared with the achromatic color of SRs in E1, the SRs presented in chromatic color in E2 were more visually attractive and easier to remember. The effect of color on memorizing shapes of SRs could be explained that color increased attention and enhanced learners' memory of the VIs (Mijksenaar, 1997; Olurinola & Tayo, 2015; Pettersson, 1998, 2010, 2019; Winn, 1993). Therefore, color coding also showed significant effects on memorizing the shapes of SRs.

The effect of the combinations of the illustrations and the color coding: In Study C, the results showed that memorizing SRs with color-coded integrated illustrations had the highest accuracy among the five prototypes for answering all three questions. Prototype E4 was a simple aggregation of the illustrations (E3) and the color coding (E2). Prototype E5 was a color-coded integrated illustration. Comparing E4 and E5, the only difference was the color of the illustrations.

The results of the accuracy showed that E5 had significantly higher accuracy than E4 for memorizing the meanings of SRs. Hence, the color-coded integrated illustrations (E5) had significantly better effectiveness for memorizing the meanings of SRs than the simple aggregated combination of color coding and illustrations (E4). The results of the RRQs showed that E5 had higher (not significantly) accuracy than E4 in both IT and DT. The accuracy in the DT of E4 and E5 both had a significant decrease, compared to their accuracy in the IT. This indicated that the effect of E4 and E5 for memorizing the shapes of SRs had been reduced to some extent after seven days. However, the accuracy of E5 was nearly significant (the *p*-value was close to 0.05) higher than E4 in DT, which implied that the effectiveness of E5 was stronger than E4 in DT. Therefore, for memorizing the shapes of SRs, although the difference between E4 and E5 was not significant, E5 still had a better effect than E4. Regarding the effects of memorizing the positions of the SRs, the results of accuracy in IT showed that E5 was significantly higher than E4. However, the high accuracy of E5 in IT had a significant decline in DT. Similar to the results of the RRQs, E5 was more effective than E4 for memorizing the positions of SRs.

Therefore, the color-coded integrated illustrations in E5 had the highest effectiveness among the other four samples, in terms of memorizing the meanings, shapes, and positions of the SRs. The integrated illustrations in E3 had the second-highest effectiveness. The effect on memorizing meanings was long-lasting while the effect on memorizing shapes and positions was not always long-lasting. However, the color coding and the integrated illustrations showed significant benefits for memorizing shapes and positions of SRs in long-term memory (at least seven days). The effect on

long-term memory was not as good as on short-term memory, because forgetting is natural for most people.

This study contributes to knowledge in the field of information and instructional design, by showing the significant benefits of using VIs for memorization. More specifically, it provides evidence that color-coded integrated illustrations significantly improve the effectiveness of memorizing SRs by non-specialist beginners, in terms of accuracy. To the best of our knowledge, this is the first study to introduce the concept of color-coded integrated illustrations with SRs and the first to test its effectiveness. The findings of this study can improve the effectiveness of self-learning materials of SRs that can be used in multiple learning mediums such as textbooks, flashcards, mobile applications, and self-learning websites. The findings in the interview showed that non-specialist beginners relied heavily on the self-learning of CCs and SRs. The findings of this study enhance the effectiveness of self-learning SRs by non-specialist beginners.

6.2. Major findings in Information and Instructional Design

The effectiveness of integrated illustrations for enhancing memorizing Chinese SRs has been verified and discussed. This study provides further findings for wider application and impact in the field of Information and Instructional Design.

First, illustrations in monochromatic color (color-coded illustrations) show no significant difference from illustrations in chromatic color for memorizing, particularly for memorizing information about meanings and shapes. While Pettersson (2019) states that chromatic colors draw more attention than achromatic colors, for reading and memorizing in VIs, this study finds that illustrations in monochromatic colors (single hue) have a similar effect to illustrations in chromatic colors (multiple hues). Illustrations in monochromatic colors can be used in VIs when displaying complex visual information. This seems to be because chromatic colors increase visual complexity, which in turn might decrease the effectiveness of perceiving complex information.

Second, this study allows us to make suggestions about using color coding for enhancing memorization in general. For example, color-coded illustrations do not weaken the effectiveness of color coding in enhancing memory. In Study C, color-coded illustrations show significantly higher accuracy for memorizing the positions of SRs than color-coded SRs. That is to say, the combination of color coding and integrated illustrations reinforces the effectiveness of color coding for memorizing the positions of SRs in this study. It is because the color-coded illustrations (monochromatic color) are more informative and visually simplified than multiple chromatic colors.

For a general memorizing purpose (not focused on memorizing SRs), the combination of color coding and illustrations does not diminish the effect of color-coding. Therefore, it is suggested that color coding can be combined with illustrations. What calls for special attention is that the colors used for color coding and the combined illustrations should be consistent. The results of Study C provide evidence that mixing illustrations in multiple chromatic colors and single hue color-coding together diminishes the effect of color coding on memory.

Regarding methodology, this study used mixed research methods to investigate the effectiveness of VIs with users. The preliminary qualitative study identified the research gap and research questions. Then, mixed qualitative and quantitative studies developed and examined the effectiveness of VIs for enhancing memorizing SRs. The mixed research methods used in this study helped to provide diverse types of evidence. The methods used in this study can be used to explore the usability of information and instructional design for enhancing memorization. Appropriate adjustments might be necessary to meet some special needs when similar methods are used for investigating the usability of design in different areas. However, exploring issues of design, user needs, and the interaction between users and design, are general aims for using these methods in combination. This is true because these methods complement each other and consequently increase the validity and reliability of the findings, as well as the immediate applicability of the findings to real-life contexts and their impact on user performance and perception.

6.3. Future research

Generalizing groups of learners who use VIs for memorizing SRs or CCs can be investigated in future research. This study investigates the VIs of memorizing SRs for general adult non-specialist beginners. The group of learners can be generalized in future research to other groups. First, VIs for learners of different ages (e.g., adolescent learners and child learners) can be further explored in future work. The VIs explored in this study should be beneficial to adolescent learners as well. However, they are a different group of learners who will have their specific needs and expectations.

Regarding child learners, although illustrations are suitable for children, integrated illustrations maybe not. There is no evidence yet as to whether children can distinguish integrated illustrations from SRs or CCs. CCs are perceived as pictures by western learners. Therefore, interactive VIs or co-learning VIs (e.g., co-learning VIs for children and parents) can be a new way to explore. Second, VIs for learners with different cultural backgrounds can be further investigated. For example, heritage language learners (e.g., British-born Chinese) are also a different group of general L2 learners and might have different needs and expectations. Third, VIs for learners with special conditions might need different VIs for memorizing CCs. For example, color-blind (or color-weakness) learners and learners with dyslexia. Therefore, the effectiveness of VIs for enhancing memorizing CCs for different groups of learners can be further explored in future research.

For memorizing purposes, integrating illustrations into textual information or photos allows presenting multiple information as a meaningful whole, which is easy to be understood and effective to be memorized, as it is in line with cognitive load theory (Ayres & Sweller, 2005; Chandler & Sweller, 1991, 1992; Ward & Sweller, 1990). Therefore, the effectiveness of integrated illustrations to enhance memorization of other knowledge (e.g., biology) can be explored in future research.

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