Effective visual instructions for Chinese characters learning: The specific case of learning Chinese semantic radicals by non-specialist beginners

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The candidate confirms that the work submitted is their own, except where work which has formed part of jointly authored publications has been included. The contribution of the candidate and the other authors to this work has been explicitly indicated below. The candidate confirms that appropriate credit has been given within the thesis where reference has been made to the work of others.

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Abstract

Learning Chinese as a second language (L2) is important for the global economy, culture and education in the future. The acquisition of thousands of Chinese Characters (CCs) is one of the big challenges for learners. Compared to specialist learners, non-specialist learners have their particular learning situations and challenges. For example, learning Chinese is not the main work for non-specialist learners. Therefore, non-specialist learners have less time to learn and practise CCs than specialist learners do. Previous research shows benefits and difficulties of learning Semantic Radicals (SRs) for the acquisition of CCs by beginners. Therefore, this study focuses on exploring the effectiveness of Visual Instructions (VIs) for assisting in learning Chinese SRs by non-specialist learners, particularly beginners.

Literature was reviewed to develop the theoretical foundation for the primary research conducted, including the knowledge of CCs and the effectiveness of VIs. An interview, an observation and a visual survey were conducted to complement the findings that emerged from the literature review and define the research question: what VIs are effective for enhancing learning CCs by non-specialist beginners? Then, five studies were conducted to examine the effectiveness of VIs in enhancing learning SRs. The first three studies were focused on exploring the VIs for Reading & Memorising SRs, the fourth study investigated the VIs for writing SRs, and the last study examined the VIs for Reading & Memorising and writing SRs.

The results indicate that the VI for Reading & Memorising SRs with colour-coded integrated illustrations significantly benefits learning SRs, including memorising meanings, shapes and positions of SRs, in terms of short-term and long-term memory (at least seven days). Specifically, the VIs with colour-coded integrated illustrations significantly increases the accuracy and speed of answering questions in memory tests. The stroke-by-stroke VI for writing SRs with colour hints and arrows significantly increases the accuracy of writing SRs for short-term memory. The use of colour hints in the stroke-by-stroke VI significantly decreases the error numbers of inaccurate stroke order. The use of arrows in the stroke-by-stroke VI significantly reduces the error numbers of inaccurate stroke directions. These research-based findings are an important contribution to knowledge and inform design and research when it comes to learning SRs by non-specialist beginners.

Contents

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List of Abbreviations

CC	Chinese Character
CCRQ	Chinese Character Recall Question
DT	Delayed Test
ID	Information Design
IT	Immediate Test
L1	First Language
L2	Second Language
MCQ	Multiple Choice Question
MRQ	Meaning Recall Question
PK	Prior Knowledge
PR	Phonetic Radical
PRQ	Position Recall Question
RQ	Ranking Question
RRQ	Radical Recall Question
SR	Semantic Radical
SW	Shapiro-Wilk
VI	Visual Instruction
WSR	Wilcoxon Signed-Rank

1 Introduction

1.1 Context

Chinese is important for communication in the future global economy. For example, Chinese was ranked as the fourth priority language in 2013 and rose to the second in 2017 in the British Council's report Languages for the future (Tinsley and Board, 2013; 2017). Chinese Characters (CCs) play a vital and irreplaceable role in the acquisition of Chinese as a second language (L2).

This study is targeted at non-specialist learners, which is defined as language learners who are not taking degrees that are named with the language name, e.g., BA Chinese studies (Canning, 2011). For learning Chinese in the UK, university electives and Confucius Institute[1] provide courses for non-specialist learners. Fifty universities in the UK provided electives for learning Chinese in 2019 (Morley and Campbell, 2019). For example, 'Language Centre' at the University of Oxford, 'Language for All' at the University of Leeds, and 'Learning-a-language' at the University of Reading. Thirty Confucius Institutes (Confucius Institute, 2014) provide Chinese courses in the UK. For example, Confucius Institute at the University of Liverpool, Confucius Institute for Scotland in the University of Edinburgh and London Confucius Institute.

Canning (2011) reported that Chinese was one of the most popular languages for non-specialist language learners in the UK. Canning (2011) also stated that the learners of Chinese considered the course to be more complicated than they had expected. CCs are a great challenge and create a heavy cognitive load for L2 learners, including the complex orthographic structure and the large number of CCs (Shen, 2005; Sung and Wu, 2011; Poole and Sung, 2015; Qian et al., 2018). This challenge is particularly great for L2 learners whose L1 is alphabetic (Shen, 2005; Nguyen et al., 2017). The difficulties in the acquisition of CCs depend on many factors, while the common challenges are to identify, recall and write CCs (Jaganathan and Lee, 2014). To be more specific, many scholars (e.g., Xu et al., 2014; Lü et al., 2015; Zhang et al., 2016; Nguyen et al., 2017) indicated the benefits and challenges of learning Semantic Radicals (SRs) and Zhang (2014) pointed out the difficulties of writing CCs with accurate writing rules.

[1] The Confucius Institute is an educational organisation funded and organised by Hanban (affiliated with the Chinese Ministry of Education) (Confucius Institute, 2014). Confucius Institutes provide Chinese courses, aimed at adult learners who are interested in learning Chinese in their spare time.

An effective Visual Instruction (VI) could be a solution for enhancing learning CCs by non-specialist beginners. A few studies have been conducted to investigate the effectiveness of images (Wang and Thomas, 1992; Kuo and Hooper, 2004; Lai and Newby, 2012), multimedia instructions (i.e., Chen et al., 2013) and animations (Xu et al., 2013) for assisting in learning CCs or SRs. However, the results of the previous studies are inconsistent. For example, Wang and Thomas (1992) argued in favour of the benefits of images for the short-term memory of CCs, while Kuo and Hooper (2004) reported a non-significant benefit of learning CCs with images. Moreover, previous research mainly focused on the perspective of language teaching, while the quality and formats of images were ignored.

In addition to the academic research, a variety of VIs for assisting in learning CCs has appeared in the market, like the book *Chineasy Everyday: The world of Chinese Characters* (Hsueh, 2016) and the mobile application *Learn Chinese with Zizzle* (Lohove, 2015). Some emerging VIs for learning CCs have not been tested yet, like integrated illustrations with CCs (e.g., Hsueh, 2016), and colour coding (e.g., Peter, 2013). Moreover, only a few studies explored the effectiveness of static VIs for self-learning SRs by non-specialist beginners. Therefore, it is essential and meaningful to investigate the effectiveness of VIs for enhancing learning SRs by non-specialist beginners.

1.2 Aim and objectives

This study aims to examine the effectiveness of VIs for enhancing learning CCs by non-specialist beginners. Four objectives are set to achieve this aim.

Objective 1: to explore the basic knowledge of CCs and understand the real-life context for learning and teaching CCs in order to identify the research gap in the field of VIs for learning CCs.

Objective 2: to investigate the theories on the effectiveness of VIs and survey existing cases using VIs for learning CCs.

Objective 3: to examine the effectiveness of different VIs for Reading & Memorising[2] SRs.

Objective 4: to examine the effectiveness of different VIs for writing SRs.

[2] VIs for Reading & Memorising SRs are the VI designed for memorising SRs by reading the VIs. The symbol & is used for clarity, especially when the VIs for Reading & Memorising SRs and the VIs for writing SRs are written together, i.e., VIs for Reading & Memorising and writing SRs.

1.3 Research questions

Research question: what VIs are effective for enhancing learning CCs by non-specialist beginners?

The research question was divided into six sub-questions in Table 1-1. The first two sub-questions, the third and fourth sub-questions, and the fifth and sixth sub-questions correspond to Objectives 1, 2, 3 and 4 respectively.

Table 1-1. Research sub-questions and the related objectives.

Research sub-questions		Objectives
1	What is the basic knowledge of CCs and how to acquire the basic knowledge of CCs?	Objective 1
2	What is the real-life context for learning CCs by non-specialist beginners in the UK?	
3	What theories support the effectiveness of VIs for learning CCs, including Reading & Memorising and writing CCs?	Objective 2
4	What types of VIs were used in the existing cases?	
5	What VIs improve the effectiveness of Reading & Memorising SRs by non-specialist beginners?	Objective 3
6	What VIs improve the effectiveness of writing SRs by non-specialist beginners?	Objective 4

Note: CC = Chinese Character; SR = Semantic Radical; VI = Visual Instruction

1.4 Structure of the thesis

To achieve the aim and objectives, this study can be divided into two major parts: the first part explores the context and builds the theoretical foundation of this study. The second part examines the effectiveness of different VIs for Reading & Memorising SRs and writing SRs.

More specifically, **Chapter 2** introduces the research methods used to achieve the aim and objectives of this study. This chapter explains in more detail what research methods were chosen to answer the research questions and why. Moreover, it also reviews research methods used in studies with a similar focus. The two parts of the study are clarified next.

FIRST PART: Chapter 3 focuses on the subject of learning CCs as an L2. Literature is reviewed that looks at the basic knowledge of CCs and the education and VIs of CCs. An interview with students and teachers, and an observation of a Chinese language course are also described and discussed. **Chapter 4** centres on the topic of the effectiveness of VIs. The literature of theories for increasing the effectiveness of VIs and the design principles of different visual elements are reviewed. It also describes and discusses a visual survey looking at the existing cases of VIs for assisting in learning CCs.

SECOND PART: Chapter 5 describes studies on the effectiveness of VIs for Reading & Memorising SRs, including Study 1 on the existing cases, Study 2 on the prototypes, and Study 3 on the new design. **Chapter 6** reports Study 4 on the effectiveness of VIs for writing SRs. As the variables of the VIs for writing SRs are not as many as the VIs for Reading & Memorising SRs in Chapter 5, the exploration of VIs for writing SRs are simpler than the VIs for Reading & Memorising SRs. **Chapter 7** details Study 5 on the effectiveness of VIs for Reading & Memorising and writing SRs. In order to verify the results of studies in Chapters 5 and 6, the VIs are tested with an expanded sample size of SRs.

Finally, the main results of Chapters 5, 6 and 7 are brought together to conclude and answer the research questions. **Chapter 8** summarises and discusses the major findings from this study and its contributions to knowledge. The suggestions for future work in this area of study are also discussed.

2 Methodology

2.1 Introduction

This study uses mixed qualitative and quantitative methods to explore the effectiveness of VIs in enhancing learning CCs by non-specialist beginners. Mixing research methods allows better understanding and multiple perspectives on the same subject (Greene et al., 1989; Kaplan, 2016).

In the first part of this study, mainly qualitative methods were used in order to understand the knowledge of learning CCs and VIs. More specifically, the first part focuses on understanding how we learn CCs, the theories about VIs, the status of research and real-world contexts within the research topic, as well as on identifying the research gap and building the research questions. To this end, a literature review was the main method. The first part has two chapters: Chapter 3 looks at the knowledge of CCs and learning CCs, while Chapter 4 looks at the effectiveness of VIs. Therefore, the two chapters have separate literature reviews based on the corresponding topics. Simultaneously, an interview, an observation and a visual survey were used to narrow down the wide range of research and to check if real-life situations align with the literature review.

In the second part of this study, mainly quantitative methods were used to examine the effectiveness of design solutions of VIs for enhancing learning CCs. The main measurements of the effectiveness were conducted through memory tests and participant opinions. Experimental studies were the main method of the second part, and the findings gathered by the qualitative methods conducted in the first part were essential and used to discuss and validate the findings from the experimental studies.

2.2 Methods in the study of CCs

2.2.1 Literature review

A literature review was conducted in the domain of learning CCs, especially for L2 beginners. The literature review was used to explore the body of knowledge in the fields covered by this study, to provide a firm theoretical foundation and to address a research gap (Hart, 1998; Webster and

Watson, 2002; Levy and Ellis, 2006). In order to build the basic knowledge of learning CCs, literature was searched, selected and reviewed, including books, chapters, journal papers, conference papers, official documents, PhD theses and official websites. The literature review started with a Keyword-search method (Levy and Ellis, 2006), then followed a Backward-search method and a Forward-search method[3] (Webster and Watson, 2002). The keyword searching was started with *CCs.* After a certain amount of research and an interview with Chinese langauge teachers, the keywords were expanded to include: *SRs* or *Radicals*, *stroke order (sequence)*, *Chinese morphemics*, *writing (handwriting)* or *written Chinese* and *Chinese script.*

In terms of selecting literature, books, book chapters, and peer-reviewed papers were the main sources reviewed. The others were published PhD theses, official documents, websites and so on. Academic books and book chapters about studies of CCs or Chinese languages were also reviewed to build the knowledge for this study. Peer-reviewed papers in academic journals, conference proceedings and published PhD theses were reviewed to build the knowledge of learning CCs by beginners, specifically focusing on how learning SRs enhance the acquisition of CCs. The reviewed papers were mainly in the fields of language and education, psychology and cognition. Reference books (e.g., dictionaries and encyclopaedias) and textbooks about CCs were cited to support some definitions of terms. Official documents and websites were cited to support this study, e.g., the Chinese language usage in standard documents issued by the National Language Commission and Ministry of Education of the People's Republic of China. Most of the reviewed literature about CCs were written in English while only a few were in Chinese. All the Chinese literature was referenced according to the requirement of Leeds Harvard reference style for foreign language materials.

For the purpose of exploring previous research about using VIs to enhance the acquisition of CCs, the keyword searching was started with *VIs* and *CCs.* However, few studies contained those two keywords. Therefore, the hypernym[4] or hyponymy[5] of the keywords were used for searching. In other words, *images, graphics, animations* or *colour* were searched because they are hyponymies of

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[3] When conducting the literature review, if a qualified article is found, a further review of its references, keywords or authors is defined as the Backward-search method; and a further review of other articles which cited the qualified article is defined as the Forward-search method (Webster and Watson, 2002; Levy and Ellis, 2006).

[4] A hypernym is a word with a broad meaning that constitutes a category. For example, *fruit* is the hypernym of *apple.*

[5] A hyponymy is a word with a specific meaning that belongs to a category. For example, *apple* is the hyponymy of *fruit*.

VIs in this research. *Multimedia* was searched as a keyword because it is a hypernym of VIs in this research. Research studies about using VIs for enhancing learning CCs were reviewed. Regarding learning CCs, the keywords contained *learning CCs*, *SRs* and *strokes*.

In order to review the contributions and methodologies of previous research to the specific topic, only peer-reviewed journal papers were investigated to help answer this question, as it stated that peer-reviewed mechanisms ensure the quality of the published work (Davison et al., 2005). The articles selected for this review were analysed concerning learners, learning goals, underlying theories, methodologies and results to inform this study.

2.2.2 Interview and observation

With the purpose of studying the real-life situations of learning CCs as L2 beginners, a semi-structured interview[6] and an overt class observation[7] were conducted. The interview collected qualitative data of opinions or experience by asking questions (Leedy and Ormrod, 2010; Qu and Dumay, 2011; Denscombe, 2014; Muratovski, 2015). The observation was a strategy used for getting close to people who were involved in the activities of this study. An observation and an interview are often used as complementary methods (Patton, 2002; Emerson et al., 2011; Crouch and Pearce, 2013). These two methods were conducted simultaneously to the literature review.

The methodologies used for understanding the status of learning CCs addressed the predetermined research questions and identified the research questions for the next stage. This stage provided a wealth of information and foundation to contextualise this study.

[6] A semi-structured interview has a list of questions with a flexible order, which aims to discover in addition to checking specific answers (Denscombe, 2014).

[7] An overt observation means that participants are fully informed when the observation is conducted (Crouch and Pearce, 2013; Ary et al., 2018).

2.3 Methods in the study of VIs

2.3.1 Literature review

The literature review about VIs looked at underlying theories from the field of cognitive psychology to explain why VIs are able to make learning more effective. The cognitive theories clarify why human process messages more effectively via VIs than not. Then, it explored that various visual design elements functioned as different learning tools. The methods used to conduct the literature review on VIs was the same as the methods described above, i.e., Keyword-search, Backward-search and Forward-search methods.

Before exploring the visual design elements for learning, the general literature about VIs for learning was reviewed. The keyword searching was not restricted to *VIs for enhancing learning*. The synonyms or near synonyms of *VIs for enhancing learning*, like *instructional design*, *multimedia*, *infographic, graphic* and *visual aids for learning*, were involved in the literature review. Then, it looked at design elements, like *images* and *colours* for enhancing the acquisition of knowledge. Subsequently, different design elements and their design principles for enhancing the effectiveness of learning were reviewed.

The main types of literature were books and peer-reviewed journal papers, while conference papers and academic websites were cited as additional material to fill in some gaps in knowledge. The reviewed cognitive theories supported the assumption that VIs enhanced the effectiveness of learning CCs by beginners. The reviewed literature about design elements and principles provided theoretical suggestions for the instructional design. The consistency between the design suggestions and the existing cases was checked in the visual survey discussed next.

2.3.2 Visual survey

A visual survey was conducted to explore existing cases that used VIs for assisting in learning CCs, including search, selection, depiction and analysis. A visual survey is a study of existing images, shapes and objects in visual materials (Muratovski, 2015; Rose, 2016). The visual survey aimed to investigate how existing designs align with the theoretical suggestions and what ideas in the existing designs informed this research.

The specific research scope in this study was to explore how VIs enhanced the effectiveness of learning Chinese SRs by non-specialist beginners. The search and selection of the existing cases were wider than the initial research scope defined for the visual survey. This was because the existing cases available for the specific topic were very limited. As a result, the scope of the visual survey was expanded. For example, existing cases for learning CCs by elementary school students were also included in the visual survey. A detailed account of the expansion of the criteria is explained later in Section 4.3.1.

A compositional interpretation and a content analysis were conducted after the selection of existing cases. The compositional interpretation is a primary research method in a visual survey that uses accurate terminologies to describe the basic information of visual materials, such as colour and size. The content analysis is another essential method that involves summing and counting variables in the visual materials (Muratovski, 2015; Rose, 2016). Conducting compositional interpretation and content analysis provided a detailed and concrete understanding of how the existing cases enhance learning CCs in real-world contexts. The alignments of the literature review with the existing cases were discussed.

In summary, the literature review investigated the underlying theories to support why and what VIs enhance the effectiveness of learning and provided design suggestions for the studies that follow. The visual survey defined the status of the field of this research in real-life contexts by surveying what types of design exist. Moreover, it addressed the gap between the theories and the existing VIs in the field for learning CCs. The study of VIs further identified the research gap for the subsequent experimental studies.

2.4 Methods in experimental studies of learning SRs with VIs

2.4.1 Methods used in previous studies with a similar focus

Limited research has been conducted to study the effectiveness of VIs for learning CCs or SRs. Seven studies (Table 2-1) were identified that explored the impact of images, animations and multimedia on enhancing learning CCs or SRs. Although these studies mainly focused on language education rather than VIs, the methods used can be adopted in this study.

Table 2-1. Methodology used in previous studies with a similar focus.

Study (reference)	Methodology			
	Methods	Participants	Tasks	Measurement(s)
No. **1** (Wang and Thomas, 1992)	Learn-and-test (experiment)	University students PK=None	MCQ memory test MRQs IT and DT (2 days and 1 week)	Accuracy
No. **2** (Jin, 2003)	Learn-and-test (experiment)	University students PK= Year 1 to 4	MCQ memory test Questions (Not described) IT only	Accuracy
No. **3** (Kuo and Hooper, 2004)	Learn-and-test (experiment) Survey (learning-strategies)	High school students PK=None	MCQ memory test CCRQs IT and DT (1 week)	Accuracy and speed
No. **4** (Lai and Newby, 2012)	Learn-and-test (experiment)	University students PK=None	MCQ memory test RRQs MRQs IT and DT (4 weeks)	Accuracy
No. **5** (Chen et al., 2013)	Pre-test and post-test (Quasi-experiment)	Chinese heritage learners PK= different	MCQ memory test RRQs IT only	Accuracy
No. **6** (Xu et al., 2013)	Pre-test and post-test (experiment)	University students PK= at least 450 CCs	Lexical decision memory test MRQs Writing task IT and DT (4 weeks)	Accuracy
No. **7** (Wang, 2014)	Learn-and-test (experiment)	University students PK=None	MCQ memory test MRQs IT only	Accuracy

Note: CC = Chinese Characters; CCRQ = Chinese Character Recall Question; DT = Delayed Test; IT = Immediate Test; MCQ = Multiple Choice Question; MRQ = Meaning Recall Question; PK = Prior Knowledge; RRQ = Radical Recall Question

Studies No. 1, 2, 3, 4, 6 and 7 conducted experimental studies while study No. 5 conducted a quasi-experimental study. All seven studies evaluated the effectiveness of VIs via memory tests. Studies No. 1, 2, 3, 4 and 7 had learn-and-test memory tests. Participants in study No. 5 had different Prior Knowledge (PK) and participants in study No. 6 have learnt about 450 CCs. To avoid participants' different PK influencing the results of the experiments, participants were asked to do a pre-test and a post-test separately in studies No. 5 and No. 6. Study No. 2 tested students from year one to year four as four different groups. Studies No. 1, 3, 4 and 7 tested ab initio beginners (PK = none). Therefore, studies No. 1, 2, 3, 4 and 7 conducted learn-and-test memory tests rather than pre-tests and post-tests. Apart from memory test, study No. 3 also had a post-test survey to ask opinions about learning-strategies.

In terms of specific tasks and measurements in the memory tests, studies No. 1, 2, 3, 4, 5 and 7 used Multiple Choice Questions (MCQs) in their memory tests and study No. 6 used lexical decisions in its memory test. Studies No. 1, 4, 6 and 7 had Meaning Recall Questions (MRQs), which means that participants were asked to recall the meaning when they were offered a CC or an SR. Studies No. 3, 4 and 5 had CC Recall Questions (CCRQs) or Radical Recall Questions (RRQs), which means that participants were asked to recall a CC or a radical when they were offered a textual meaning. Study No. 4 had both MRQs and RRQs (two ways). Study No. 6 also had a writing task.

All seven studies had an Immediate Test (IT) after the learning task. Studies No. 1, 3, 4 and 6 also had a Delayed Test (DT) after the IT. The lengths of delayed days varied in different studies (refers to the column of Tasks in Table 2-1). All seven studies measured the effectiveness by the accuracy in the memory tests. Study No. 3 also measured the effectiveness by the speed of answering the questions. Moreover, studies No. 2 and 6 used identical or similar stroke number to control the difficulty of different CCs or SRs, which was not mentioned in other studies.

The following methods are those identified and adopted from previous studies:

1) A learn-and-test task can be used for testing the effectiveness of VIs for learning SRs by ab initio beginners.
2) A post-test survey about opinions of different VIs can be used to complement the results of the memory test.
3) MCQs can be chosen as the question form.
4) Short-term memory can be examined by an IT and long-term memory can be reviewed by a DT.
5) Stroke numbers can be used to control the difficulties of SRs. SRs with the identical or similar stroke number represent identical or similar difficulties.
6) The effectiveness of VIs can be measured in memory tests through accuracy and answering speed.

2.4.2 Experimental methods used in this study

Experimental methods were chosen to use in this study with the intention of examining the effectiveness of different VIs for Reading & Memorising SRs and writing SRs. The empirical studies contained Study 1, Study 2, Study 3, Study 4 and Study 5 for achieving the objectives as listed in Table 2-2.

Table 2-2. The experimental methods in this study.

Objectives	Study	Methods	
To examine the effectiveness of different VIs for Reading & Memorising SRs.	Study 1	Quasi-experimental study	30 participants Learn-and-test task (IT) Ranking task
	Study 2	Two usability tests	5 participants X 2 usability tests Learn-and-test task (IT) Post-test survey
	Study 3	Experimental study	30 participants Learn-and-test task (IT and DT) Post-test survey
To examine the effectiveness of different VIs for writing SRs.	Study 4	Experimental study	30 participants Writing task (IT) Post-test survey
To examine the effectiveness of different VIs for Reading & Memorising and writing SRs.	Study 5	Experimental study	30 participants Learn-and-test task (IT and DT) Writing task (IT and DT) Post-test survey

Note: DT = Delayed Test; IT = Immediate Test

Study 1, Study 2 and Study 3 were conducted to explore and test the effectiveness of VIs for Reading & Memorising SRs. Study 4 was conducted to investigate and test the effectiveness of VIs for writing SRs. Study 5 was conducted to examine the effectiveness of VIs for Reading & Memorising and writing SRs. Different methods were used in the five studies, and they will be explained next.

Quasi-experimental study: a quasi-experimental study was conducted in Study 1 to explore the effectiveness of VIs in existing cases. A quasi-experimental study is usually used when the independent variables cannot be fully under controlled for practical reasons (Field and Hole, 2002). In Study 1, the VIs in existing cases show some independent variables, for example different layouts and presentation sizes, which had to be kept as the original design and therefore could have had an influence that was not possible to control.

Ranking task: in Study 1, a ranking task was conducted with participants to measure the ease of Reading & Memorising SRs of different VIs in the existing cases. The ranking was a question format and a measurement to explore the participants' opinions (Oldendick, 2008; Finch, 2017). In Study 1, the participants were not allowed to rank any VIs at the same level. The forced ranking was suggested as an effective strategy to avoid some VIs that were rated at the same level and then it could show an explicit answer (Sauro, 2018; Vannette, 2019). The ranking task in Study 1 was conducted with visual examples from the existing cases, since providing visual examples was suggested as an effective way to organise a ranking task (Oldendick, 2008).

Usability test: iterative usability tests were conducted to test and evaluate the prototypes of VIs for Reading & Memorising SRs in Study 2. An iterative usability test is suggested as one of the most effective methods to find and improve design issues (Moran, 2019). Moreover, the usability tests also evaluated the feasibility of the process of the study and then helped prepare the materials for the experiments that followed.

Experimental study: experimental studies were conducted in Study 3, Study 4 and Study 5. All the experimental studies were within-subjects studies where the same participants test all conditions, i.e., different VIs. The opposite of a within-subjects study is a between-subjects study, as it means different groups of participants test each condition (Field and Hole, 2002; Price et al., 2015; Budiu, 2018). A within-subjects study reduces the influence of non-experimental variables dramatically. For example, in this study, different language learners usually have different abilities of learning and memory. Moreover, a within-subjects study is more economical to run, i.e., less time and cost (Field and Hole, 2002; Price et al., 2015; Budiu, 2018). The primary limitation of a within-subjects study is carry-over effect that the participants' behaviours are affected by different VIs in this study. Randomisation is suggested as an effective approach to minimise the Carry-over effect (Field and Hole, 2002; Price et al., 2015; Budiu, 2018). According to Price et al. (2015), the Research Randomizer website (2020) is suggested as a useful tool to generate randomised sequences for different conditions. Therefore, different materials were shown to participants with different sequences in Study 1, Study 3, Study 4 and Study 5.

IT and DT: the five studies all had an IT. Study 3 and 5 also had a DT after seven days. In Study 3, the IT and the DT for examining the effectiveness of VIs for Reading & Memorising SRs were conducted online through Google Forms. However, the IT was conducted in-lab because it was conducted after the learning task. All the participants were asked to do the DT in a private and undisturbed environment. Collecting data online reduced the burden for participants (Reips, 2002; Finley and Penningroth, 2015). Study 5 contained the Reading & Memorising and writing tasks. Therefore, to conduct the writing task, both the IT and the DT were conducted in-lab in Study 5.

Post-test survey: Study 2, Study 3, Study 4 and Study 5 all had a post-test survey to explore participants' opinions. A five-point Likert scale questionnaire with visual examples was used to allow the participants to express how much they agreed or disagreed with a specific function and the effectiveness of VIs. A five-point Likert Scale is one of the most frequently used tools in questionnaires (Hinkin, 1998).

Sample size: Study 1, Study 3, Study 4 and Study 5 had 30 participants respectively (120 participants in total). It is recommended that a sample size of 30 participants for behaviour research provides valid data (Roscoe, 1975). Study 2, with two iteration usability tests, had five participants per test. It is suggested that conducting usability test with no more than five users is sufficient to identify design issues (Nielsen, 2000).

The five studies were conducted in a private and quiet environment where the process of testing would not be interrupted. All the tested SRs in the five studies were the common SRs in Chinese (Discover China, 2020) (refers to Appendix I). All the writing stroke order and directions in the VIs in Study 4 and 5 followed the published standard writing of CCs (National Language Committee, 1997).

2.5 Summary

This study combined qualitative and quantitative methods to investigate the effectiveness of VIs for enhancing Reading & Memorising and writing SRs by non-specialist beginners. Qualitative methods were used in the first part of this study to build the theoretical framework in the perspectives of learning CCs and VIs respectively. The methods used in the first part achieved the first two objectives and answered the first four sub-questions separately.

The review of the literature about learning CCs, the interview and observation explored the real-life context for learning CCs, which answered the first two sub-questions. The literature review about VIs and the visual survey of existing cases provided both theoretical suggestions and current situations of design in the real-life situation, which responded to the third and the fourth sub-questions.

Quantitative methods (e.g., experimental studies) were primarily used in the second part of this study to examine the effectiveness of different VIs for learning SRs. Some qualitative data was also collected (e.g., participants' opinions) to complement the quantitative findings of the experiments. The methods used in the second part answered the last two sub-questions. Some methods in the experimental studies were commonly used in the previous studies, like the learn-and-test task (e.g., Wang and Thomas, 1992; Jin, 2003), the MCQ tests (e.g., Kuo and Hooper, 2004; Lai and Newby, 2012) and using stroke numbers to control the difficulties of different SRs (e.g., Jin, 2003; Xu et al., 2013). Some methods were infrequently used in previous studies, like the post-test survey (e.g., Kuo and Hooper, 2004).

In order to explore the effectiveness of VIs, this study conducted more experiments for Reading & Memorising SRs than writing SRs, for two reasons. Firstly, for learning a new SR, beginners typically start from Reading & Memorising. Then they write it for assisting in memorisation. Therefore, in this study, the memory task was the primary task, while the writing task was the secondary task. Secondly, the VIs for Reading & Memorising SRs have far more variables than those for writing SRs. Therefore, the experiments for investigating VIs for Reading & Memorising SRs are more than those for writing SRs.

3 Chinese Characters (CCs)

3.1 Introduction

In orders to explore the effectiveness of VIs for enhancing learning CCs, the knowledge of CCs, literature review, an interview and observation, were conducted simultaneously. First, this chapter will start with the literature review to introduce the knowledge of CCs, which needs to be understood in this study. Then, the findings of the interview and observation will be reported and discussed to support and complement the findings of literature review.

To help understand the content of Chapter 3, the concepts of compound CCs and SRs are briefly introduced here and then explained in detail in Section 3.2.1.2. CCs have single-component CCs and compound CCs (Chen, 2001; Lu, 2016). In compound CCs, an SR provides meaning information and a Phonetic Radical (PR) provides phonetic information (Shen and Ke, 2007; Xu et al., 2014).

3.2 Literature review

The literature review will clarify what basic knowledge of CCs and learning CCs needs to be obtained in this study. Then, as SRs play an important role in CCs, the knowledge of SRs and the benefits of learning SRs will be discussed. Lastly, previous studies that investigated the effectiveness of VIs for enhancing learning CCs are also discussed.

3.2.1 The knowledge of CCs

The wealth and splendour Chinese culture has evolved over a long history of thousands of years. Language is manifestly one of the most crucial parts of a culture. Hence, CCs originated from around 3000 years ago (Bagley, 2004). After developing for thousands of years, some features of the original CCs remain, and some have been lost. The following introduces the origin and development of CCs firstly, and then explains the constitution and rules of modern CCs.

3.2.1.1 The origin and development of CCs

Pictograms are the origin of CCs (Wieger, 1965; Xu and Duan, 1981; Norman, 1988), which means that many CCs were created as pictures to represent their meanings. Oracle bone script is the earliest (around 1200 BC) confirmed evidence of Chinese script (Bagley, 2004). Many of oracle bone scripts are Pictograms or Pictograms-derivative CCs (Liu, 2009). Figure 3-1 shows examples of oracle bone CCs: Mountain, Vehicle, Tiger and See. Their meaning can be identified from graphical features.

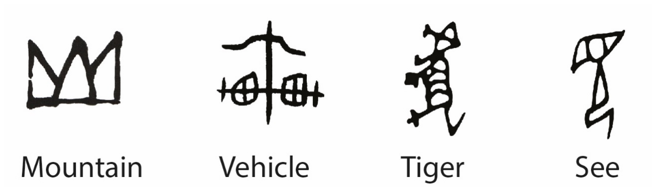


Figure 3-1. The oracle bone CCs Mountain, Vehicle, Tiger and See.

However, using only pictures (Pictograms) cannot meet the requirements of communications and records in daily life. Five other formations of CCs emerged, and some Pictogram CCs were used as components in new CCs. The Six-Categories of CCs were first raised by Xu Shen in Shuowen Jiezi[8] in the Eastern Han Dynasty (AD 25-189) (Wieger, 1965; Xu and Duan, 1981; Norman, 1988). The Six-Categories of CCs are Pictograms [Xiang Xing][9], Simple ideograms [Zhi Shi], Semantic-Phonetic-Compound CCs [Xing Sheng], Compound ideograms [Hui Yi], Rebus characters [Tong Jia] and Derivative cognates [Zhuan Zhu].

Many scholars (e.g., Wieger, 1965; Wang, 2011) state that the first four categories can explain the majority of CCs very clearly and the last two categories sometimes bring confusion. Moreover, three Chinese teachers who were interviewed for this study (further discussed in Section 3.3) also mentioned that the last two categories were no longer used in teaching, especially for beginners. Thus, the last two categories will not be discussed further in this study. The explanation for the first four categories of CCs is as follows (Wieger, 1965; Xu and Duan, 1981; Norman, 1988) (Figure 3-2):

[8] Shuowen Jiezi (Xu, 2013) was the first Chinese dictionary to analyse the structure of CCs and was the first to use SRs as sections to organise CCs.

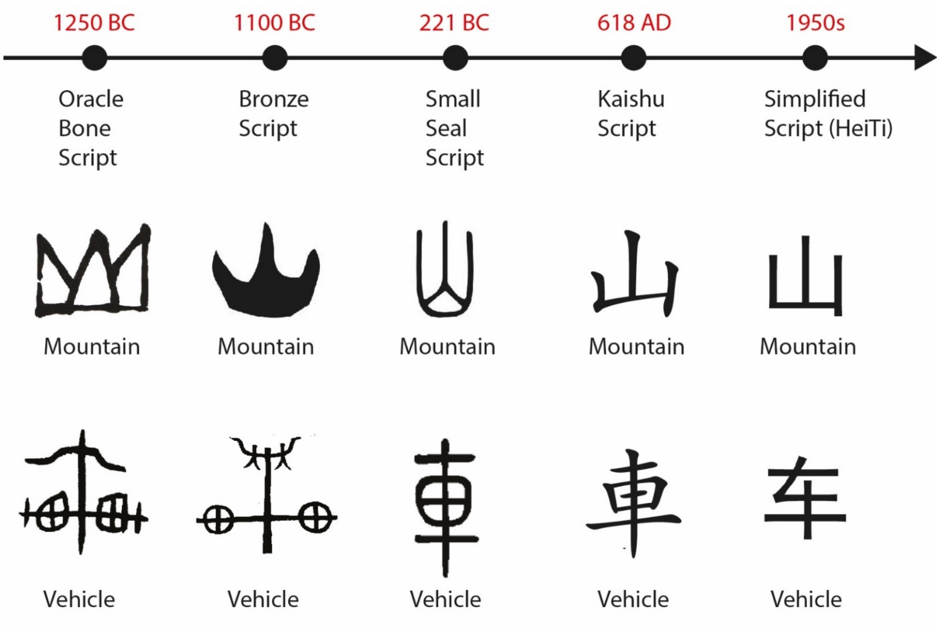
[9] All the six categories have different English translations in different books. To avoid confusion, the Chinese pronunciations Pinyin (spelling sounds) of the six categories are written in brackets.

1) **Pictograms** [Xiang Xing]: a rough draft that represents the objects – e.g., CC Mountain looks very similar like the shape of mountains.
2) **Simple ideograms** [Zhi Shi]: a figure that suggests the meaning in an abstractly way – e.g., CC On (or Over) indicates the meaning of 'on' or 'over'.
3) **Semantic-Phonetic-Compound CCs** [Xing Sheng]: made with an SR to provide semantic information and a PR to offer phonetic clue – e.g., CC River has SR Water to indicate the meaning, and PR Work suggests the pronunciation.
4) **Compound ideograms** [Hui Yi]: made with an SR and one or more components. An SR provides semantic information, and the other components provide semantic supplements – e.g., CC Bright has SR Sun and the component Moon. Both of them indicate the meaning of bright.

Categories	Example	Graphical explanation
Pictograms [Xiang Xing]	山 **CC Mountain**	
Simple ideograms [Zhi Shi]	上 **CC On/ Over**	
Semantic- Phonetic -Compound characters [Xing Sheng]	江 **CC River**	
Compound ideograms [Hui Yi]	明 **CC Bright**	

Figure 3-2. Examples and graphical explanations of the first four categories out of the Six-Categories of CCs.

After more than 3000 years of development, some CCs keep their pictorial meanings, while some others have already lost their original graphical meanings in this process. For example, Figure 3-3 shows the evolution of Pictogram CCs (examples: CC Mountain and CC Vehicle) from oracle bone script (around 1250 BC) to simplified script (around 1950s). The CCs presented and used in this study are the simplified script, which are used in mainland China from about 1950s. The simplified CC Mountain still keeps its pictorial meaning after more than 3000 years of development. However, the simplified CC Vehicle has already lost its original graphical identifiability from its oracle bone script (Norman, 1988). Moreover, Pictogram CCs are very small parts (about 1%) of CCs in contemporary time (DeFrancis, 1989) and that is why some teachers hold a negative impression about using pictures to teach CCs in the interview in Section 3.3.



Reference: (Norman, 1988; Mair, 1996; Li, 2002; Ditter, 2009)

Figure 3-3. The evolution of Pictogram CCs (examples: CC Mountain and CC Vehicle) from the oracle bone script to the simplified script.

In summary, CCs originated from Pictograms. The earliest oracle bone script is the evidence. As the demand for the language grew, five other ways of creating new CCs emerged, called the Six-Categories of CCs. Only the first four categories are discussed in this study. Pictograms, being one of the six categories, also played a semantic role in other categories of CCs. However, after three thousand years of evolution, some Pictogram CCs still keep their pictorial meanings while others have lost their pictorial features. Moreover, the amount of Pictogram CCs only account for around 1% of all CCs in contemporary time. This section introduced CCs according to the development in time. The following section will introduce the constitution and rules of CCs in the contemporary time.

3.2.1.2 The constitution and rules of CCs

CCs are structurally divided into single-component CCs and compound CCs. Compound CCs are the majority (about 80%) of CCs (Chen, 2001; Lu, 2016). Compound CCs are built by more than one component while single-component CCs are built by only one component. Figure 3-4 shows examples of single-component CC Female and CC Child, and a compound CC Good. The compound CC Good is composed of the Female component and the Child component. The shapes of the Female and the Child components are similar to the CC Female and CC Child. Concerning the categories of CCs (refers to Section 3.2.1.1), most Pictograms and Simple ideograms are single component CCs, while all the Semantic-Phonetic-Compound CCs and Compound ideograms are compound CCs. Pictograms and single-components CCs are both small portions of CCs (DeFrancis, 1989; Chen, 2001; L1, 2013; Lu, 2016).

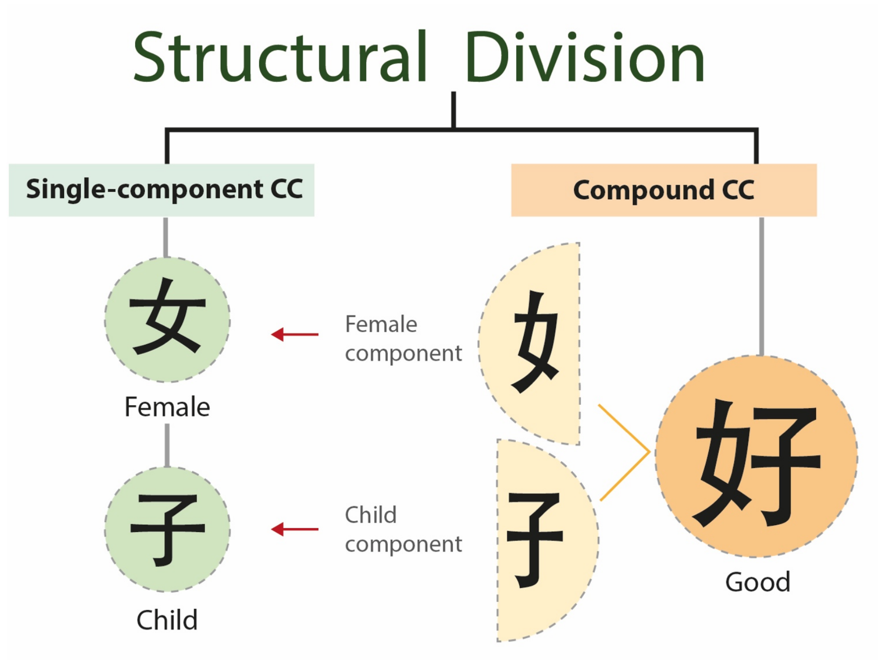


Figure 3-4. Structural division of CCs: single-component CCs and compound CCs (examples: CC Female, CC Child and CC Good).

CCs are composed of components and the components consist of strokes (Shen and Ke, 2007; Jaganathan and Lee, 2014; Xu et al., 2014). Figure 3-5 illustrates the constructional units in compound CCs with CC Good as an example. A Chinese component is the smallest meaningful unit of a CC which cannot be further divided. When the components have constant meanings and fixed positions in compound CCs, they are called SRs. When the components offer phonetic clues to compound CCs, they are called PRs (Shen and Ke, 2007; Xu et al., 2014). The rest of the components provide meaning supplements to compound CCs. There are 201[10] SRs and around 800 PRs in standard CCs (Hoosain, 1991; Wang et al., 1999; Institute of Linguistics, The Chinese Academy of Social Sciences, 2011). It is suggested that the semantic cueing function of SRs is stronger than the phonetic cueing function of PRs (Shu et al., 2003; Ho et al., 2003). The strong semantic cueing function will be introduced in Section 3.2.2. Regarding PRs, it is stated that the accuracy of the phonetic cues to compound CCs is about 40% and it drops to 23% if considering tones of CCs (Zhou, 1980; Shu et al., 2003). Moreover, teachers pointed out the benefits of learning Chinese SRs in the interview in Section 3.3. Therefore, PRs will not be further introduced in this study.

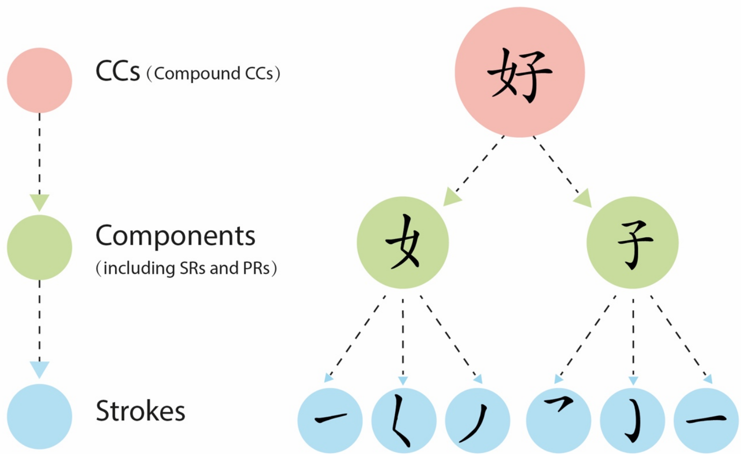


Figure 3-5. Constructional units in compound CCs (example: CC Good).

Strokes are the lowest and most basic units in CCs, which build up components or build up single-component CCs directly (Jaganathan and Lee, 2014). Strokes are also the basic units of writing CCs. Fixed stroke order and directions are the rules of writing CCs. Writing CCs accurately could simplify and speed up the writing process (Jaganathan and Lee, 2014; Zhang, 2014). In 1997, the National Languages Committee in the Ministry of Education of the Republic of China published a book about standard writing of CCs (National Language Committee, 1997), which confirmed the importance of

[10] There were 540 SRs in Shuowen Jiezi (Xu, 2013) in the Eastern Han Dynasty (AD25-189). The number of SRs reduced to 214 in 1615 in Zihui (Xue, 1982). Nowadays, the standard number of SRs is 201, which were reported by the Ministry of Education of the People's Republic of China (Lihua, 2009).

accurately writing CCs. Figure 3-6 shows the writing rules of the fixed directions of the eight basic strokes. For example, the horizontal stroke should be written from left to right rather than right to left. Figure 3-7 shows the six steps of writing CC Good in the fixed stroke order. The stroke in each step that needs to be written was highlighted in red.

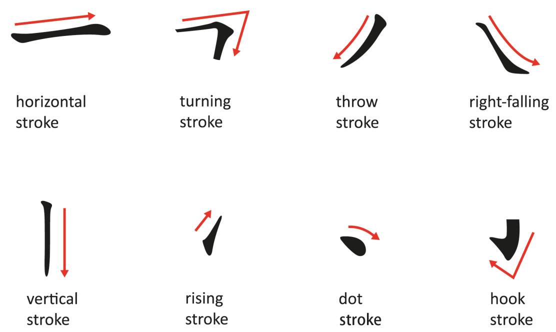


Figure 3-6. The writing rules of the fixed directions of the eight basic strokes.

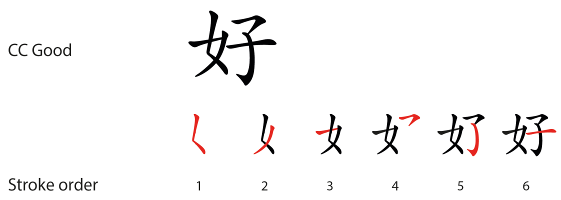


Figure 3-7. The six steps of writing CC Good in the fixed stroke order (the stroke in each step that needs to be written was highlighted in red).

Although different CCs are written in different stroke order, six general rules should be followed. Figure 3-8 shows the six rules with four CCs as examples.

- Rule 1: writing horizontal strokes before vertical strokes.
- Rule 2: writing throw strokes before right-falling strokes.
- Rule 3: writing CCs from top to bottom.
- Rule 4: writing CCs from left to right.
- Rule 5: writing CCs from outside to inside.
- Rule 6: writing a sealing stroke last.

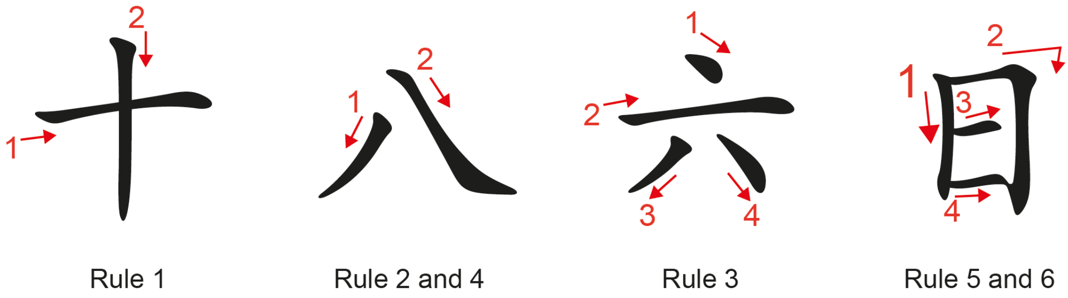


Figure 3-8. CC examples for explaining the writing Rule 1 to Rule 6.

A survey was conducted to investigate the origins of common SRs in Chinese in this study. By checking origins of 92 common SRs in Chinese[11] in Shuowen Jiezi (Xu, 2013) and Xinhua Dictionary[12] (Institute of Linguistics, The Chinese Academy of Social Sciences, 2011), the results showed that 71 SRs originated from Pictograms, 12 SRs originated from Compound ideograms, five SRs originated from Simple ideograms and four SRs originated from Semantic-Phonetic-Compound CC. Appendix I lists the origins of the 92 common SRs. The results showed that the majority of the common SRs originated from Pictograms, which contained their graphical features. Compound CCs, which are built by SRs and components, are the majority (about 80%) of CCs (Chen, 2001; Lu, 2016). Therefore, the most common SRs still contain graphical features, which offer meaning cues to the majority of CCs (compound CCs).

To sum up, CCs have single-component CCs and compound CCs. Compound CCs are the vast majority (around 80%) of CCs. In regard to the constitution of CCs, strokes build components and components build CCs. SRs are crucial components in compound CCs. The majority of the common SRs originated from Pictograms. The rules of writing CCs assist in writing CCs accurately.

[11] A list of common radicals in Chinese was provided by Discover China (2020). It shows 110 common radicals, including 92 SRs. The textbook Discover China (Anqi et al., 2010) was designed for non-specialist adult learners. This book was used in some Universities'electives of Chinese language, e.g., 'Language for All' at the University of Leeds, and some Confucius Institutes, e.g., Lancaster University Confucius Institute.

[12] 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.

3.2.2 Learning SRs

3.2.2.1 Properties of SRs

The properties of Chinese SRs include the semantic function, the positional regularity and the various combinability. The semantic function means that Chinese SRs provide semantic cues to compound CCs (Wang et al., 1999). The majority of SRs deliver direct meaning cues while a small number of SRs provide indirect meaning cues. Fixed positions of Chinese SRs are the positional regularity. The various combinability indicates that some SRs compose more CCs than others. Apart from properties of SRs, the nomenclature and exceptions of SRs will also be explained.

The semantic function: most SRs provide direct meaning cues to compound CCs, although there are some exceptions (Wang et al., 1999). Taking SR Heart (vertical)[13] as an example (Figure 3-9), CC Affection, CC Sympathy, CC Memory, CC Fear, CC Regret and CC Anger all have direct semantic associations with the meaning of heart. However, some CCs do not have a direct semantic association with its SRs. For example, CC Busy and CC Quiet have indirect meaning associations with heart. Hoosain (1991) called the first situation (SRs that provide direct meaning cues to compound CCs) as semantically transparent; and the second situation (SRs that do not provide direct meaning cues) as semantically opaque. The majority (approximately 87%) of compound CCs have semantically transparent SRs (Kang, 1993).

Figure 3-9. Examples of SR Heart (vertical) and related CCs for explaining semantically transparent SRs and semantically opaque SRs.

[13] Some SRs show differences in vertical and horizontal presentation. For example, 忄 is SR Heart (vertical) and 心 is SR Heart (horizontal).

The positional regularity: SRs have fixed positions in compound CCs. For example, the SR Heart (vertical) (Figure 3-9) is always on the left sides in compound CCs. This is similar to English affixes, like prefixes (before a root word) and suffixes (after the root word) (Master, 1996). For instance, the prefix *anti-* is always placed before a root word, like *antibiotics* and *antivirus*. The suffix -*able* is always placed after a root word, like *manageable* and *comparable*. However, the positions of Chinese SRs are more complex than English affixes. Generally, Chinese SRs have six different positions (Figure 3-10): left (left-top and left bottom), top, right, bottom, outside and inside. The left position has extra two varieties: left-top and left-bottom (Chen, 1983). More than half (61%) of compound CCs have left SRs (Wang, 2009). The top SRs and bottom SRs are also popular in compound CCs (Chen, 1983). However, it is stated that the right-side radicals (SRs or PRs) have greater influence on the recognition speed of CCs rather than the left-side radicals (Taft and Zhu, 1997). This means people pay more attention to right sides of compound CCs than left sides. Since more than half of SRs are on the left sides of compound CCs and easily to be ignored, it is important to develop effective instructions for enhancing learning SRs.

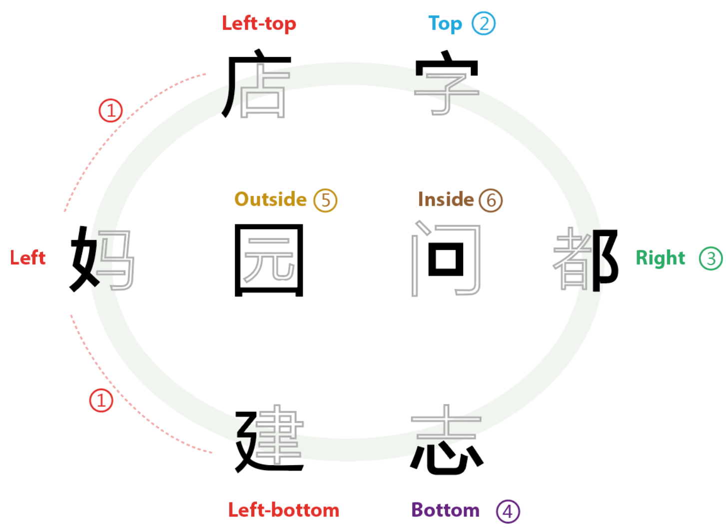


Figure 3-10. Six positions of SRs in compound CCs.

The various combinability: some SRs compose more compound CCs than other SRs (Nguyen et al., 2017). The high combinability SRs mean the SRs compose many CCs. For example, the high combinability SR Water (氵) compose 1036 CCs (Institute of Linguistics, The Chinese Academy of Social Sciences, 2011). The low combinability SRs mean the SRs compose little CCs. For example, SR Dark (玄) composes five CCs (Institute of Linguistics, The Chinese Academy of Social Sciences, 2011).

Nomenclature: there are some SRs that 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 3-11). In this study, the nomenclature used will be SR [meaning] (vertical) and SR [meaning] (horizontal) if the same-meaning SRs have different positions. For example, the SR Heart (vertical) and the SR Heart (horizontal).

Figure 3-11. SR Heart (vertical), CC Memory, SR Heart (horizontal) and CC Miss.

Exceptions: generally, the positions for almost all SRs are in accordance with the language rules. However, there are a few exceptions. For example (Figure 3-12), SR Rice is normally on the left of compound CCs, e.g., CC Food, CC Seed and CC Cake. However, the SR Rice is in the middle of CC Porridge. In this study, since the target audience is non-specialist beginners and the exceptions are always in complicated CCs and very few, such exceptions are not considered.

Figure 3-12. SR Rice and CCs Food, Seed, Cake and Porridge.

In summary, this section explained the semantic function, the positional regularity and the various combinability of Chinese SRs. The three properties apply to the most Chinese SRs. The exceptions and the nomenclature were explained. The semantic function indicates the strong semantic connection between CCs and SRs in compound CCs. The various combinability shows the benefits of learning SRs. That is to say, the acquisition of high combinability SRs assists the acquisition of a large amount of compound CCs.

3.2.2.2 Benefits of learning SRs

Previous research investigated the effects of the knowledge of SRs on the acquisition of CCs from different perspectives. Table 3-1 lists 12 previous studies that were published in peer-reviewed journals in chronological order. In these 12 studies, four studies (from No. 1 to No. 4) explored the effect with first language (L1) learners, and eight studies (from No. 5 to No. 12) explored it with L2 learners. Table 3-1 shows the details of the 12 studies, which are not repeated. The main findings showing the benefits of learning SRs in the 12 papers are reported next.

For L1 learners, it is stated that the knowledge of SRs benefits the recognitions of CCs (Shu and Anderson, 1997; Feldman and Siok, 1999; Ho et al., 2003; Wong, 2017). To be more specific, the knowledge of SRs is suggested to be introduced to child L1 learners at an early stage (Ho et al., 2003). The younger the L1 learners are, the less knowledge of SRs they have (Shu and Anderson, 1997; Wong, 2017). The semantic and positional knowledge of SRs are important for the acquisition of new CCs as child L1 learners (Ho et al., 2003).

For L2 learners, the eight studies (from study No. 5 to No. 12) investigated how the knowledge of SRs influenced the acquisition of CCs. First, it is demonstrated that introducing the knowledge of SRs to L2 learners earlier is significantly better for learning CCs than introducing the knowledge of SRs later (Taft and Chung, 1999). Xu et al. (2014) found that the knowledge of SRs led to a significantly better recall of CCs in the beginner level group while the knowledge of SRs did not lead to a significant difference in the intermediate level group. Therefore, more benefits of learning SRs were found for L2 beginners than for a higher level L2 learners. Second, the knowledge of SRs facilitates learning CCs for various levels of beginners. Four studies (Su and Young-Suk, 2014; Lü et al., 2015; Zhang et al., 2016; Nguyen et al., 2017) tested the effect of learning SRs with beginners who had different lengths of learning experience (from four months to one year) and they all demonstrated that the knowledge of SRs facilitated learning CCs. Third, the knowledge of SRs is more beneficial for the acquisition of CCs than the knowledge of PRs for L2 learners (Tong and Yip, 2015).

To sum up, the knowledge of SRs benefits the acquisition of CCs for L2 beginners and child L1 learners. Introducing the knowledge of SRs to learners at an earlier stage is more beneficial than a later stage. However, the benefits of SRs are under-utilised to help learn CCs (McGinnis, 1999). Traditionally, rote memorisation is suggested as a useful method for learning CCs and SRs, especially for writing practice (McGinnis, 1999; Taft and Chung, 1999; Ho et al., 2003; Nguyen et al., 2017). However, rote learning is generally time-consuming and discourages learners. Research of emerging instructions for enhancing learning CCs and SRs will be introduced next.

Table 3-1. Previous studies about the effects of the knowledge of SRs on the acquisition of CCs.

Study	Participants (Learners)			References
	L1 Learners			
	Elementary school students			
	N	**Grade** (N for groups)	**L1**	
No. 1	220 +72	Grade 1 (67) Grade 3 (71) Grade 5 (82)	Chinese	(Shu and Anderson, 1997)
No. 2	60 + 60	Grade 1 (40) Grade 3 (40) Grade 5 (40)	undescribed	(Ho et al., 2003)
No. 3	142	Grade 5 (All)	Chinese	(Wong, 2017)
	University students			
No. 4	64 + 60	undescribed	Chinese	(Feldman and Siok, 1999)
	L2 Learners			
	Middle/ High School students			
	N	**Chinese level** (N for groups)	**L1**	
No. 5	34	4 Months elective Chinese classes	Mixed (English, Spanish, Bosnian, Vietnamese)	(Zhang et al., 2016)
	University students			
No. 6	10 × 4	Total beginners PK= None	undescribed	(Taft and Chung, 1999)
No. 7	140	One month (35) One year (35) Two year (35) Three year (35)	Exclude students from Asian language backgrounds.	(Shen and Ke, 2007)
No. 8	97	All > one semester	91- English 6- Spanish, Dutch, etc.	(Su and Young-Suk, 2014)
No. 9	48+40	7-hour for 8 weeks (48) PK=180 CCs and 40 SRs 40=7-hour for 36 weeks (40) PK=530 CCs	undescribed	(Xu et al., 2014)
No. 10	48	Semester 3 PK= SR were not taught explicitly	Mixed participants from western and eastern countries.	(Lü et al., 2015)
No. 11	84	Average 3.45 years' experience in learning Chinese	72=Indo-European language 12=Non-Indo-European language	(Tong and Yip, 2015)
No. 12	54	First 2 months of the second academic year	All=Vietnamese	(Nguyen et al., 2017)

Note: CC = Chinese Characters; L1 = First Language; L2 = Second Language; N = Number; PK = Prior Knowledge; SR = Semantic Radical

3.2.3 Emerging instructions for enhancing learning CCs and SRs

To assist rote memorisation, many emerging instructions appeared. VIs played an important role in the emerging instructions, like pictures in the book *Chineasy Everyday: The world of Chinese Characters* (Hsueh, 2016). The emerging instructions are used to assist in learning rather than being a replacement of the rote memorisation. However, only a few studies have been conducted to investigate the effectiveness of emerging instructions. Table 3-2 lists seven previous studies which explored the effectiveness of emerging instructions for enhancing learning CCs and SRs in chronological order. What has been investigated and what can be learnt from the previous studies will be discussed next.

Firstly, six studies used pictures (including animated pictures) as an instructional element to visualise the meanings of CCs (No. 1, 3 and 7) and SRs (No. 2, 4 and 5). Studies No. 1 and 4 demonstrated that pictures had significant advantages in IT but no advantages in DT (Wang and Thomas, 1992; Lai and Newby, 2012). Study No. 7 reported that animations worked significantly better than textual-only instructions in IT (Wang, 2014). The animations in study No. 7 are short, animated pictures rather than long storytelling animations. Study No. 2 and 5 suggested that multimedia instructions (including pictures) worked significantly better than traditional instructions (excluding pictures) for learning SRs in IT (Jin, 2003; Chen et al., 2013). Apart from Study No. 6, the other six studies all used dual coding theory. Study No. 4 also used cognitive load theory. These two theories will be explained in Section 4.2.1.

However, Kuo and Hooper (2004) (No. 3) 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 IT and DT. They also stated that the single-coding group with pictures was no better than the single-coding group with text in both IT and DT. Therefore, the effectiveness of pictures for learning CCs and SRs is still debatable. This might be because the quality of the pictures was not given the needed focus in some studies. Study No. 1 (Wang and Thomas, 1992) and No. 3 (Kuo and Hooper, 2004) described the testing pictures as meaning representations without providing actual pictures. Studies No. 2, 4, 5 and 7 showed examples of testing pictures or animations (Figure 3-13). Apart from the animations in study No. 7 (Wang, 2014), the pictures in studies No. 2, 4 and 5 are small and unattractive. This suggests that the quality of pictures was not an important consideration in the previous studies, which might have influenced the effectiveness of the instructions.

Table 3-2. Previous studies about emerging instructions for enhancing learning CCs and SRs.

Study	Instructional goals	Instructional elements	Theories	References
No. 1	CC-Meaning	• Imagery-based instruction • Rote learning	Dual coding theory	(Wang and Thomas, 1992)
No. 2	SR-Meaning Stroke order Pinyin[14]	• Animated image • Animation • Sound & text	Dual coding theory	(Jin, 2003)
No. 3	CC-Meaning	• Translation • Verbal description • Picture representation • Translation, verbal description and picture representation • Self-generation	Dual coding theory	(Kuo and Hooper, 2004)
No. 4	SR- Meaning and the application in CC	• No cue • Static pictures • Gradient static pictures • Animated pictures • Mental Imagery	Dual coding theory Cognitive load theory	(Lai and Newby, 2012)
No. 5	Radical awareness Stroke order	• Multimedia instruction • Traditional lecture instruction	Dual coding theory	(Chen et al., 2013)
No. 6	CC-stroke order	• Reading • Animation (stroke order) • Writing	None	(Xu et al., 2013)
No. 7	CC-Meaning	• Text or Animation only • Animation + text or narration	Dual coding theory	(Wang, 2014)

Note: CC = Chinese Character; SR = Semantic Radical

[14] Pinyin is the official Romanisation spelling-sound for CCs.

Figure 3-13. Examples of the tested materials in studies No.2, No.4, No.5 and No.7.

Secondly, very few studies explored static instructions for writing CCs or SRs. Studies No. 2, 5 and 6 suggested that animations showed benefits for instructing stroke order for experienced learners (Jin, 2003; Chen et al., 2013; Xu et al., 2013). However, there does not seem to be any experimental research exploring the effect of static VIs on writing CCs or SRs, especially for beginners. VIs for writing CCs in textbooks generally have two ways to show stroke order: the stroke-by-stroke VI (Figure 3-14) and the all-in-one VI (Figure 3-15) (Zhang, 2014). The stroke-by-stroke VI shows stroke order in steps. The all-in-one VI uses numbers to highlight the order of strokes in one CC. The effectiveness of the two VIs for writing CCs and SRs is unclear (Zhang, 2014).

Figure 3-14. The stroke-by-stroke VI for writing CC Good.

Figure 3-15. The all-in-one VI for writing CC Good.

Thirdly, three different typefaces were used to display CCs or SRs in the previous studies. Apart from handwriting texts in study No. 1 (Wang and Thomas, 1992), studies No. 2, 3 and 4 displayed CCs in Songti typeface (Jin, 2003; Kuo and Hooper, 2004; Lai and Newby, 2012), studies No. 5 and 6 used Kaiti typeface (Chen et al., 2013; Xu et al., 2013) and study No. 7 used Heiti typeface (Wang, 2014). Figure 3-16 shows the CC Good which is displayed in Songti, Kaiti and Heiti typefaces separately. Different Chinese typefaces have different legibility (Zhang, 2011), which will be further explained in Section 4.2.3.4. There does not seem to be any research paying attention to the typefaces in VIs for learning CCs or SRs.

Figure 3-16. Examples CC Good displayed in Songti, Kaiti and Heiti typefaces.

Previous studies of emerging instructions explored the effectiveness of pictures (including short animations) for enhancing Reading & Memorising CCs or SRs and different results were found. Some scholars state that pictures (including short animations) significantly increase the effectiveness of learning CCs or SRs in IT (e.g., Lai and Newby, 2012) while other scholars hold the opposite view (e.g., Kuo and Hooper, 2004). By looking at the tested pictures in previous studies, the quality of the pictures does not seem to have been given enough attention, which might have influenced their effectiveness. The pictures were only a visual presentation of information relative to a textual presentation. Moreover, pictures in the previous research were presented with long textual explanations or other information. Therefore, the effectiveness of pictures, especially high-quality pictures, needs further exploration.

In terms of writing VIs, the effectiveness of animations for instructing stroke order has been examined (e.g., Xu et al., 2013) but the effectiveness of static VIs is not clear. Additionally, the typefaces for presenting CCs or SRs have not been given much attention either.

3.2.4 Summary

CCs originated from Pictograms, which have a graphical feature (Wieger, 1965; Xu and Duan, 1981; Norman, 1988). After thousands of years of development, Pictogram CCs only account for a very small proportion (about 1%) of all CCs in contemporary time (Defeyter et al., 2009). However, the graphic feature of CCs is retained and presented on many SRs in contemporary time, because the majority (71 out of 92 SRs) of common SRs (Appendix I) were identified as originating from Pictograms. Chinese SRs, the smallest meaning units of compound CCs, are essential components of compound CCs, which are the majority (80%) of CCs (Chen, 2001; Lu, 2016). In terms of the graphical feature of SRs and the number of CCs associated with SRs, the knowledge of SRs benefits the acquisition of CCs. Moreover, many scholars (e.g., Su and Young-Suk, 2014; Xu et al., 2014; Lü et al., 2015; Zhang et al., 2016; Nguyen et al., 2017) have demonstrated that the knowledge of SRs benefits the acquisition of CCs as L2 beginners.

The properties of SRs indicate the knowledge of SRs should include the meanings, shapes and positions of SRs (Chen, 1983; Wang et al., 1999). The graphical feature of SRs should be considered for developing VIs. According to the review of previous research, the effectiveness of pictures for learning CCs and SRs is still debatable. The high-quality pictures for VIs need further investigation. Additionally, there do not seem to be any research exploring the effectiveness of instructions for memorising positions of SRs.

Moreover, more than half of SRs are on the left side of compound CCs (Wang, 2009), but the right-side radicals (including SRs) showed greater influence on Reading & Memorising CCs (Taft and Zhu, 1997). Therefore, most SRs can be easily ignored in compound CCs during reading. This also strengthens the need to have effective VIs to support the learning of SRs.

Regarding writing CCs or SRs, strokes are the basic units. Writing CCs and SRs following fixed stroke order and directions simplify and speed up the writing process (Jaganathan and Lee, 2014; Zhang, 2014). The VIs for writing CCs and SRs can be considered as one single process, as SRs are important parts of CCs. However, only a few studies examined the effectiveness of animations for writing CCs (e.g., Xu et al., 2013). The effectiveness of static VIs for writing SRs has not been tested. Moreover, stroke directions have not been highlighted in previous studies. Previous studies have not given importance to the typefaces for learning CCs or SRs, which might influence its effectiveness.

Therefore, the literature review thus far demonstrates the benefits of learning SRs for the acquisition of CCs by beginners. Previous research of emerging instructions cannot meet the requirement of learning SRs. This means the effectiveness of VIs for enhancing learning SRs needs further investigation. To understand the learning and teaching situation in real-life contexts and see how these align with the findings in the literature review, an interview and an observation were conducted and will be introduced next.

3.3 Interview

In order to explore the situations in a real-life context with different aspects of learning and teaching, interviews were conducted with students and teachers. All participants were asked to talk about situations for teaching and learning CCs, and their opinions regarding VIs. The following three questions were asked and then participants were free to develop their ideas and speak more widely on the issues raised by the researcher.

- Question 1: what are the challenges for students in learning CCs?
- Question 2: what methods are suggested for learning CCs?
- Question 3: are VIs recommended for learning CCs?

3.3.1 Methods

A total of four Chinese language teachers (T1 to T4) and 10 students (S1 to S10) participated in the interview. All the interviewees were identified as anonymous. Four teachers and seven students (S1 to S5 and S9 to S10) were interviewed using a one-to-one semi-structured interview method.

Student S6, S7 and S8 were interviewed using the group interview method after they just finished the HSK test[15] (Level 3). Table 3-3 shows the participants' experiences with teaching or learning Chinese.

Table 3-3. Experiences with teaching or learning Chinese of the participants in the interview.

Teachers	Experiences with teaching or learning Chinese
T1 to 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 teaching or learning Chinese**
S1 to S5	They were non-specialist beginners, as they only took three to five weeks courses (45 to 90 minutes per week).
S6 to S8	They were elementary level non-specialist learners.
S9 to S10	They were advanced level specialist learners, i.e., final year University students learning Chinese as an L2.

Note: S = Student; T = Teacher

3.3.2 Findings

3.3.2.1 Challenges for learning CCs

Participants listed several challenges for learning CCs (responding to question 1), including difficulties of using SRs, inaccurately writing and so on. Five challenges were identified as follows:

- Challenge 1: the encoding of CCs is different from alphabetic languages.
- Challenge 2: students have negative emotions when learning CCs.
- Challenge 3: students do not use Chinese SRs well when learning CCs.
- Challenge 4: students do not always write CCs in accurate stroke order and directions.
- Challenge 5: memorising CCs relies on self-learning because the class time for CCs is always limited.

Table 3-4 shows the evidence from the interview to support the five challenges for learning CCs.

[15] 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 (Hanban, 2014).

Table 3-4. Evidence from the interview to support the five challenges for learning CCs.

Evidence from the interview	Participants
Challenge 1 The encoding of CCs is different from alphabetic languages.	
'Chinese is one of the most difficult languages for western learners, which is because Chinese is too far away from their mother tongue.'	T2
'I don't know how to encode Chinese characters in my mind, you know, you cannot spell it, like English.'	S2
'It's like pictures, you cannot spell it.'	S3
Challenge 2 Students have negative emotions when learning CCs.	
'Many students showed nervousness when we had dictations on classes.'	T1
'Beginners always show negative emotions when they learn Chinese characters.'	T2
'I can tell from students' faces that they struggled to memorise Chinese characters.'	T3
'I prefer to learn pinyin.'	S3
'I don't think I can memorise that many characters.'	S4
'It takes me a long time to write it over and over again.'	S6
'I don't have much time to practise memorising and writing characters every day.'	S7
Challenge 3 Students do not use Chinese SRs well when learning CCs.	
'Semantic radicals are supposed to be a strong helper for learning, understanding and memorising Chinese characters. However, students do not always use it well.'	T1
'Students are not able to use Semantic radicals as building blocks to build Chinese characters.'	T2
'It is always arduous for beginners to understand and to use Chinese semantic radicals to learn characters.'	T3
'It is not rare to find some students writing semantic radicals in wrong places.'	T4
'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.'	S9

Note: CC = Chinese Character; S = Student; SR = Semantic Radical; T = Teacher

Table 3-4. Evidence from the interview to support the five challenges for learning CCs. *(continued)*

Evidence from the interview	Participants
Challenge 4 Students do not always write CCs in accurate stroke order and directions.	
'Many students do not think it is necessary to write characters in accurate stroke order and directions, which is a misconception.'	T2
'Writing a character in an accurate stroke order has been highlighted many times, which is very important, but students still struggle with it.'	T4
Challenge 5 Memorising CCs relies on self-learning because the class time for CCs is always limited.	
'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.'	T1
'Communicating is always the primary goal for beginners, and it is effective to practise in class. Chinese characters could be practised after class.'	T2
'They can practise characters on their worksheets after class.'	T3

Note: CC = Chinese Character; S = Student; SR = Semantic Radical; T = Teacher

3.3.2.2 Methods for learning CCs

Participants were given several different methods for learning CCs (responding to questions 2 and 3), including using pictures, showing ancient scripts and writing worksheets. All the methods had pros and cons in the real learning situation.

Using pictures – Students memorised a CC using a related picture. Student S8 said that pictures were useful for him. Students S1, S4 and S9 recommended the book *Chineasy Everyday: The world of Chinese Characters* (Hsueh, 2016) as a typical example of a picture mnemonic book, which is one of the existing cases analysed in the visual survey in Section 4.3. Teachers T1 and T3 suggested the picture mnemonic method. T1 said that she tried to find some related photos to facilitate explaining CCs. T3 showed some pictures (Figure 3-17) that were used in her class. CC Talent and CC Female were shown similar forms of illustrations. CC Individual was shown the footprints of a rooster that had a similar form. CC Eight was shown a handlebar moustache.

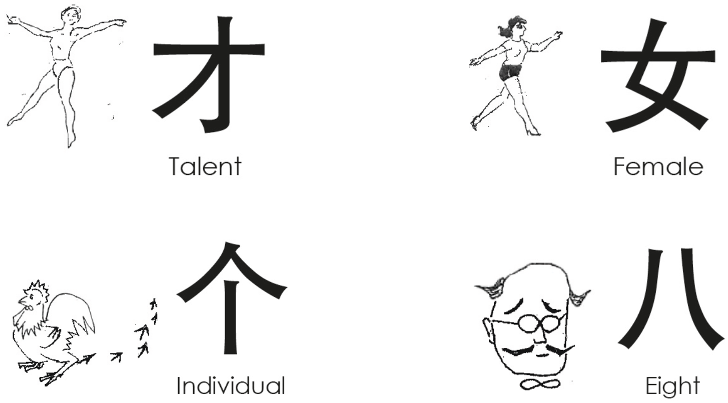


Figure 3-17. Examples of the ‘using pictures’ method discussed in the interview.

Showing ancient scripts – Students memorised a CC stimulated with a related ancient script (oracle bone script). Teachers T2 and T3 used this method for beginners. They stated that single-component CCs were usually taught with this method. T3 showed some examples, like CCs Child, Water, Wood and Ox (Figure 3-18). All the ancient scripts of CCs had similar forms to the objects. However, both teachers stated that this method had not been used frequently because only a small number of CCs had similar forms to ancient scripts.

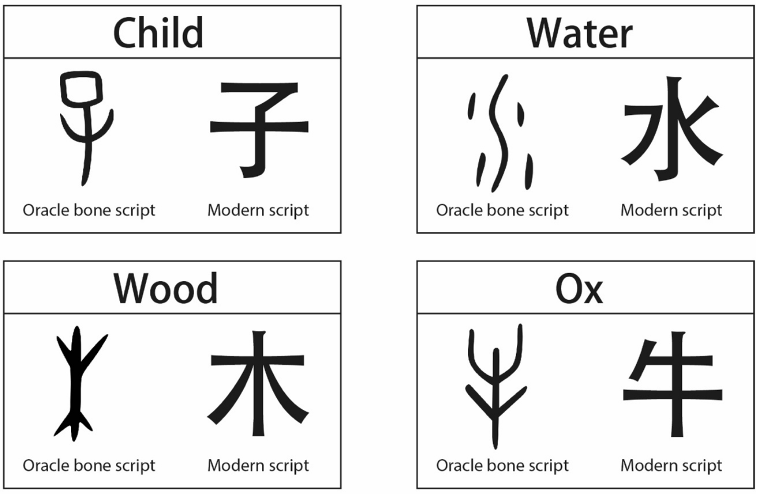


Figure 3-18. Examples of the ‘showing ancient scripts’ method discussed in the interview.

Writing worksheets – Students practised CCs after class with writing worksheets. The popular and suggested writing worksheets were always presented with ‘Tianzige’ (Style 1) or ‘Mizige’ (Style 2) line guide to show positions of each stroke of CCs. Moreover, all teachers stated that writing practice with worksheets should follow Kaiti typeface, because Kaiti typeface is the closest typeface to handwriting characters. Figure 3-19 shows the two styles of line guides with CC Wood as an example in Kaiti typeface.

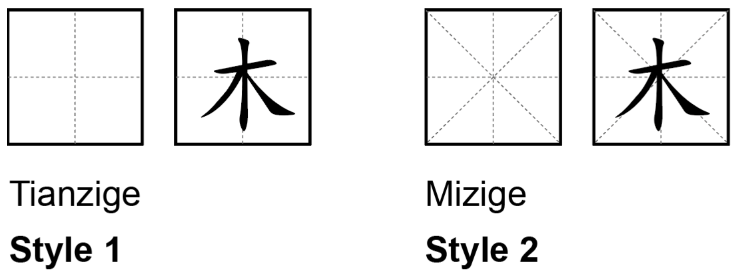


Figure 3-19. Examples of the 'writing worksheets' method discussed in the interview.

3.3.2.3 Opinions about VIs

Participants held different opinions about the effectiveness of VIs for enhancing learning CCs.

Positive opinions – Participants T1, T3, S1, S4, S8 and S9 considered VIs as an effective method for enhancing learning 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.'

Neutral opinions – Participants 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.'

Negative opinions – Participants 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.'

3.3.3 Summary

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.

First, the effect of learning SRs was reconfirmed 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 learning CCs had not been fully used. This implied VIs for enhancing learning SRs needed more research.

Second, accurately writing CCs was underlined by teachers, which was consistent with the literature review (Jaganathan and Lee, 2014; Zhang, 2014). However, inaccurate writing was one of the most common errors that students made. Writing practice was generally after class, which strengthened even more the need of effective VIs.

Participants had different opinions about VIs. Six participants agreed on the benefits of VIs for assisting in learning CCs, which aligned with some previous research (e.g., Lai and Newby, 2012). Five participants hold a neutral opinion and three participants thought that VIs should not be widely promoted. Reasons why participants hold a negative opinion are as follows. First, a teacher indicated that it was not realistic to make all CCs a specific picture, as there was a huge number of CCs. She also highlighted that most of CCs do not have graphical features. This was in line with the literature that Pictogram CCs only accounted for a small number (about 1%) of modern use CCs (Defeyter et al., 2009). It means that using pictures for enhancing learning CCs might not benefit the majority of CCs. Second, a student stated that rote learning could not be replaced by looking at pictures as repetition was still the effective way to memorise CCs. However, the purpose of VIs was to facilitate learning CCs rather than replace rote learning CCs. These different opinions about pictorial VIs showed that more research on VIs for enhancing learning CCs is needed.

Lastly, the findings of the interviews showed some realities about learning CCs. For example, learning CCs was mainly self-learning after class and it mainly relied on rote learning. The realities showed the need to find effective self-learning VIs.

3.4 Observation

To further understand the real context of teaching and learning CCs and engage with the learning and teaching process, an observation of a Chinese language course was conducted. The observation and the interview were conducted in the same period of time, without a specific order. The course was observed to identify: 1) the overall situation; 2) methods; 3) error types and 4) time duration for learning and teaching CCs.

3.4.1 Methods

The observation was conducted in a Chinese language course for non-specialist beginners, which lasted six weeks (90 mins/week). The course was offered by the Confucius Institute in the UK. One teacher and seven students from 19 to 36 years old, with a mean age of 25, participated in the observation. They were all informed of the observation.

3.4.2 Findings

Some of the findings in the observation were the same as the findings in the interview, but it brought a more in-depth understanding of the role of learning CCs when learning the Chinese language.

3.4.2.1 Overall situation for learning and teaching CCs

First, the students showed **negative emotions** when learning CCs, which were observed during class when learning CCs, e.g., silence and confused faces. The course started with the topics of greetings and nationalities. However, the related CCs were very complex, which seemed frightening to beginners. It might be one of the reasons why students have negative emotions for learning CCs. For example, CC Thank (Figure 3-20) looked complicated, and was usually introduced at the beginning for a greeting topic.

Second, the **students relied heavily on pinyin** when they read materials, especially for complicated CCs. The pinyin system has a similar alphabetic system with the Romanised script, and it might be the reason why students who come from western countries prefer to read pinyin. However, the easier the students feel it is to read pinyin, the less motivation they have to learn CCs.

Lastly, the teacher **shortly explained Chinese SRs** rather than highlighted SRs repetitively. It was also explained by the teacher that SRs might be difficult for them to understand.

Figure 3-20. CC Thank is an example of complicated CCs which is usually introduced at the beginning in a Chinese language course for a greeting topic.

3.4.2.2 Methods for learning and teaching CCs

In terms of the methods, rote memory after class was the most commonly used way to learn CCs and SRs. Apart from rote learning, the teacher used six other methods to assist memorising CCs and test the learning outcomes: 1) verbal description; 2) using pictures; 3) visualising structures of CCs; 4) dictations; 5) a Jeopardy-style game; 6) a meaning-and-character matching test. The last three methods (4, 5 and 6) that were used for teaching CCs were less related to the topic of this study. Therefore, only the first three methods are explained next.

First, the teacher used a **verbal description** to stimulate students' mental imagery of CCs and SRs. For example, to learn CC Net (Figure 3-21), the teacher asked students to imagine the CC Net like a real net. To learn SR Water, the teacher asked students to imagine the SR Water like three drops of water. However, this method was not appropriate for many CCs. For example (Figure 3-21), it is not easy to imagine CC Liquor to be real liquor and SR Crop to be a real crop.

Figure 3-21. Examples of the 'verbal description' method used in the observation.

Second, the teacher used **pictures** (similar to CCs) to facilitate understanding and memorisation of CCs. For example (Figure 3-22), the CC Net is shown with a real net photo, and the SR Water is displayed with an illustration of three drops of water. However, it is generally time-consuming for the teacher to find appropriate pictures for teaching CCs. This method was suggested for self-learning after class.

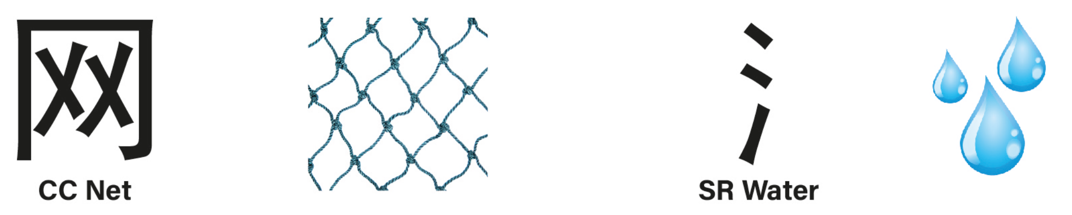


Figure 3-22. Examples of the 'pictures' method used in the observation.

Third, the teacher **visualised structures** of CCs. This method was used in the beginning to introduce the structure of compound CCs. Figure 3-23 shows how the teacher visualised structures to show a single-component CC and a compound CC.

Figure 3-23. Examples of the 'visualised structures of CCs' method used in the observation.

3.4.2.3 Error types in for learning CCs

Five types of errors were found when learning CCs during the observation. The results of the matching test and class questions showed Errors 1 and 2. The results of dictations in the class showed Errors 3, 4 and 5.

- **Error 1**: cannot recall or wrongly recalls a meaning when a CC is offered.
- **Error 2**: cannot recall or wrongly recalls a shape when CC is offered.
- **Error 3**: writes CCs in wrong stroke order.
- **Error 4**: writes CCs in wrong strokes directions.
- **Error 5**: misses stroke(s) when writing CCs.

3.4.2.4 Time duration for teaching CCs in class

Regarding the class time for teaching CCs, based on the results of the six weeks of observation, the average time was seven minutes per 90 minutes each week. The teacher indicated that memorisation was the main task for learning CCs, and they always left this task for self-learning after class. The class time was mainly used for speaking practice. The class time for learning CCs was limited.

3.4.3 Summary

The observation showed five main findings. Three findings were consistent with the main findings from the interview:

- VIs were suggested, but available VIs for learning CCs and SRs were limited.
- Students lacked motivation and showed negative emotions for learning CCs.
- Recognition, memorisation and accurately writing CCs (including SRs) were the challenges for learning CCs.

The other two findings complemented the results of the interview, as the first point was briefly mentioned by participants in the interview:

- CCs were supposed to be learnt and memorised after class, which mainly relied on self-learning. The time for teaching CCs in class was limited.
- Chinese SRs had not been highlighted repetitively in the class. Students did not have a very clear understanding of Chinese SRs.

The main findings of the interview were the challenges and methods of learning CCs, as most of them were reconfirmed in the observation. Additionally, it was found in the observation that learning CCs and SRs had limited class time and relied heavily on self-learning. The findings showed the need of an effective VI for self-learning CCs and SRs.

3.5 Conclusions

CCs are composed of components and components consist of strokes (Shen and Ke, 2007; Jaganathan and Lee, 2014; Xu et al., 2014). The majority (about 80%) of CCs are compound CCs, which are built with SRs and components (Chen, 2001; Lu, 2016). SRs provide meaning cues for compound CCs (Shen and Ke, 2007; Xu et al., 2014).

Learning SRs facilitates the knowledge of CCs for L2 beginners and it is suggested when introducing the knowledge of SRs in the early stage of learning (e.g., Su and Young-Suk, 2014; Xu et al., 2014; Lü et al., 2015; Zhang et al., 2016; Nguyen et al., 2017). It is stated that the benefits of SRs are under-utilised when learning CCs (McGinnis, 1999). Teachers in the interview emphasised the importance of SRs, but they also stated that beginners could not use SRs well to learn CCs. The findings of the interview and the observation showed that learning CCs and SRs mainly relied on self-learning after class.

The importance of accurately writing CCs (including SRs) was highlighted by teachers in the interview, and this was in line with previous studies (Jaganathan and Lee, 2014; Zhang, 2014). However, the findings of the interview and the observation indicated that inaccurately writing CCs (including SRs) was one of common errors that students made. Moreover, the findings suggested that writing practice relied on a writing worksheet.

The above findings show the importance of learning SRs for the acquisition of CCs by beginners. Based on the constitution of CCs and properties of SRs, this study explores the effectiveness of VIs for Reading & Memorising SRs, including meanings, shapes and positions of SRs. Moreover, this study also explores the effectiveness of VIs for writing SRs, including writing SRs in accurate stroke order and stroke directions.

For Reading & Memorising SRs, the graphical feature of CCs and SRs should be considered for developing VIs. CCs originated with a graphical feature, which is called Pictograms (Wieger, 1965; Xu and Duan, 1981; Norman, 1988). The numbers of Pictogram CCs reduced to 1% of all CCs after thousand years of evolution (Defeyter et al., 2009). The small number of Pictogram CCs was a typical reason why a teacher in the interview held a negative opinion for using pictures to teach CCs. However, the graphical feature is retained and presented on many SRs. This was proved by checking the origins of the 92 common SRs (Appendix I), and the results showed that 71 of the 92 SRs originated from Pictograms. Therefore, the graphical feature of SRs could be used for developing VIs for Reading & Memorising SRs.

The results of the interview and the observation showed that pictures were potentially effective method for learning SRs. A few previous studies tested the effectiveness of pictures, animated pictures and multimedia (including pictures) for learning CCs and SRs. However, they reached different conclusions. Some studies concluded that pictures (or animations) significantly increased the outcome of learning CCs or SRs in IT, but not in DT (e.g.,Wang and Thomas, 1992; Lai and Newby, 2012). Another study stated that pictures did not show significantly better outcomes for learning CCs in both IT and DT (Kuo and Hooper, 2004). As is stated in Section 3.2.3, the quality of pictures does not seem to have been taken into consideration in previous studies. Moreover, VIs, like pictures, were not tested alone, but were presented with other instructions, like long text explanations (Lai and Newby, 2012; Wang, 2014) or ancient scripts (Chen et al., 2013). Therefore, the effectiveness of pictures for learning CCs and SRs needed further research.

For writing SRs, it is suggested that writing CCs (including SRs) in accurate stroke order and directions, simplifies and speeds up the writing process (Jaganathan and Lee, 2014; Zhang, 2014). Previous studies tested the effectiveness of animations for writing CCs (e.g., Xu et al., 2013), but the effectiveness of static VIs is not clear. Moreover, only the stroke order was emphasised and tested in previous studies, while the stroke direction was ignored, which is also an important rule for accurately writing CCs. The stroke-by-stroke VI and the all-in-one VI are the two main static VIs for writing CCs but the effectiveness of them is not clear (Zhang, 2014). Teachers in the interview recommend line guides and Kaiti typeface for writing practice. In previous studies, the typefaces for showing CCs or SRs have not been given enough attention. Thereby, the effectiveness of static VIs for writing SRs need further research.

In a nutshell, the specific research aim for this thesis was defined through this scoping research as 'to explore the effectiveness of self-learning VIs for enhancing learning Chinese SRs by non-specialist beginners'. To be more specific, to explore the effectiveness of VIs for enhancing Reading & Memorising meanings, shapes and positions of SRs; and to explore the effectiveness of VIs for accurately writing SRs.

4 The effectiveness of Visual Instructions (VIs)

4.1 Introduction

The effectiveness of VIs is influenced by the goals of instructions, learner differences and features of design elements (Clark and Lyons, 2010). The purpose of information and instructional design is to effectively present, communicate and memorise information by integrating textual and visual information (Schriver, 1997; Pettersson, 1998; Horn, 1999; Zull, 2002; Simlinger, 2007). Information and instructional design are supposed to make the acquisition of knowledge more efficient and accessible (Merrill et al., 1996; Clark and Lyons,2010; Reiser and Dempsey, 2012; Pettersson and Avgerinou, 2016). In this study, assisting in learning the knowledge of SRs is the goals of instructions. Non-specialist beginners are the learners. Therefore, the theories and principles of information and instructional design, and design elements will be introduced.

In previous research, some visual design elements were used to enhance language learning. For instance, images are suggested as an effective tool for learning English (Akbari, 2008; Louie and Sierschynski, 2015), Arabic (Aldalalah et al., 2010) and Spanish (Snyder and Colón, 1988). Colour mark is recommended to increase the effectiveness of learning Russian (Birzer and Zinsmeister, 2016). Moreover, images and diagrams bring a positive impact on learning English root words (Gill, 2007), which is similar to Chinese SRs to some extent. Therefore, VIs have great potential to assist in learning Chinese SRs.

Accordingly, cognitive theories are regarded as underlying theories for the effectiveness of information and instructional design (Clark and Lyons, 2010; Pettersson, 2014; Lonsdale and Lonsdale, 2019). Literature on cognitive theories, design principles and elements is reviewed next. The theoretical and design suggestions from the literature review are used as a basis for classification and analysis in the subsequent visual survey. Then, the visual survey of existing cases using VIs for enhancing learning CCs and SRs, is introduced.

4.2 Literature review

Cognitive theories, generally used in the fields of psychology and education, build a firm foundation for information and instructional design (Pettersson, 2014; Lonsdale and Lonsdale, 2019). Cognitive theories, like the dual coding theory and the cognitive load theory, explain how humans process and memorise information. Accordingly, cognitive theories lay the foundation for effective VIs for enhancing learning CCs. Afterwards, on the basis of cognitive theories, design principles will be explained as a general guidance for analysing existing cases and exploring new VIs. Furthermore, a more specific review of different design elements will be followed.

4.2.1 Cognitive theories

Before introducing cognitive theories, it is important to explain the different types of memory, including short-term memory and long-term memory. Short-term memory is when limited information remains in the human brain for about 15 to 30 seconds (Atkinson and Shiffrin, 1971). It has a limited capacity of about only seven (plus or minus two) items that can be stored in the short-term memory (Miller, 1956). Long-term memory is the storage of information in the human brain for a long period of time (from a few minutes to a lifetime duration) (Mcleod, 2010).

Dual coding theory (Paivio, 2013; 1986; Clark and Paivio, 1991) proposes that both visual-coding and verbal-coding are independent cognitive systems for processing information in the human brain. To be more specific, people have a verbal-coding system to process linguistic information and a separate visual-coding system to process imagery and spatial information. People can retrieve information either from their verbal memory or from their visual memory. For example (Figure 4-1), if people see an apple and hear the word *apple*, they process the image information and language information separately. When visual and verbal codes are activated together, people have a better memory than activating only one of them (Mayer, 1993; Moreno and Mayer, 2000). In other words, 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 (Paivio, 1971; Clark and Paivio, 1991). Regarding VIs for learning, this theory has been used as a theoretical foundation in many studies (e.g., Vekiri, 2002; Carney and Levin, 2002).

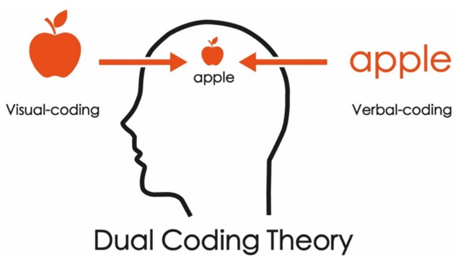


Figure 4-1. The visual explanation of the dual coding theory.

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 (Paivio, 1986; Defeyter et al., 2009; Curran and Doyle, 2011; Pettersson, 2014). It is suggested that short-term memory and long-term memory are all consistent with the dual coding theory and the picture superiority effect. According to Klatzky (1975), mental pictures are not precisely the same as external images, which emphasises the importance of providing images in VIs. Visual information facilitates international communication (Horn, 1998). In other words, visual information has a unique capacity to aid mutual understanding when different cultures meet. Moreover, visual information facilitates translation when it is composed in a multilingual document (Horn, 1998).

Cognitive load theory (Chandler and Sweller, 1991) suggests that effective VIs benefit learning by directing cognitive information. If diagrams or illustrations require learners to split their attention among various sources of information, they are less effective.

Split-attention effect refers to the phenomenon that learners are forced to split their attention when explanatory text is separate from the related diagrams or illustrations. It is explained that only little meaning could be received if diagrams or illustrations are displayed alone. The received information may be meaningless and the speed of receiving information may slow down when it is presented far away from its related text content (Ward and Sweller, 1990; Sweller and Chandler, 1991; Chandler and Sweller, 1991; 1992; Ayres and Sweller, 2005).

To avoid imposing a heavy and external cognitive load, three principles are suggested. First, the design of effective VIs should integrate multiple physical sources of information (Chandler and Sweller, 1991). Pettersson (2010) also indicates that a meaningful integrated whole work (one that includes illustrations, colours, symbols and texts as a whole) is more effective and paid more attention to than several individual elements. Second, effective VIs should be self-explanatory (Chandler and Sweller, 1991). Third, effective VIs should not have redundant information (Chandler and Sweller, 1991).

4.2.2 Visual perception principles

In addition to the principles suggested from cognitive theories, there are also general principles of information and instructional design that are of great relevance to this research study, which are presented next.

Simplicity principle – People perceive better information when graphic elements are presented in their simplest form (Pettersson, 2002; 2014; Lipton, 2011). Simplification of various design elements increases the effectiveness of VIs (Lipton, 2011). Similarly, reduction has been suggested as another fundamental design principle that directly relates to the simplicity principle (Mullet and Sano, 1995). Any insignificant elements in pictures, layouts or texts should be removed in order to present crucial information (Dewar, 1999; Wogalter, 1999). Visual complexity is defined as being excessive of details (Berlyne and Peckham, 1966), irregular shapes and incongruousness (Berlyne, 1958).

Similarity principle – People tend to perceive elements that are similar as belonging to the same group (e.g., same or similar size, shape, colour and typeface). As long as the differences between elements in a group are small and they are obviously distinct from another group, this principle works very effectively (Chang et al., 2002; Lipton, 2011; Ali and Peebles, 2013; Pettersson, 2014; Lonsdale and Lonsdale, 2019).

Focal point principle – People tend to perceive elements that have a focus of interest or are highlighted. The focal point could be emphasised by using a distinct colour or size. A focal point could be used to attract, direct and keep attention (Chang et al., 2002; Lipton, 2011; Ali and Peebles, 2013; Pettersson, 2014; Lonsdale and Lonsdale, 2019).

Contrast principle – People tend to perceive elements with a strong contrast rather than a weak contrast. The visual contrast is a relative concept. For example, an apple seems to be big when it is compared with a smaller apple, but it seems to be small when it is compared with a bigger apple (Pettersson, 2014).

4.2.3 Design elements

Different design elements have different functions for being as VIs. The typical and commonly used design elements in VIs are reviewed below.

4.2.3.1 Arrows

An arrow symbol is a typical instructive visual element that combines a line and a triangle or just lines (Pettersson, 2013a; Finkel, 2015). In the UK, the use of arrows in public signs is standardised by the British Standards Institution (2012), which is the UK implementation of ISO (the International

Organisation for Standardisation). Accordingly, arrows generally have four types: straight movement (Type 1), rotational movement (Type 2), movement of people (Type 3) and force or pressure (Type 4). Table 4-1 shows the standard four types of arrows, with standard angles and their instructed meanings. Types 1, 2 and 3 arrows all indicate movements. Types 1 and 2 are used in small scale signs of movement that have thin and light lines. Type 3 arrow indicates the movement of people that are used in large scale signs, like public wayfinding signages, which have thick and robust lines. The two ends of Type 3 arrow are parallel with the main line. Type 4 arrow shows force or pressure.

Table 4-1. Standard four types of arrows stipulated by the British Standards Institution (2012).

Types	Angles	Meanings
Type 1	60°	Movement
Type 2	60°	Rotational movement
Type 3	84° to 86°	Movement of people
Type 4	84°	Force or pressure

In addition to these, if we include the meanings of arrows suggested by the British Standards Institution (2012), then we have a total of seven different meanings of arrows in VIs: 1) to indicate causality; 2) to show sequence; 3) to provide emphasis; 4) to indicate direction); 5) to suggest movement; 6) to show pressure; 7) to show increase or decrease (Mayer, 1993; Horton, 1993; Horn, 1998; The British Standards Institution, 2012; Pettersson, 2013b). In regard to VIs for learning SRs, arrows are suggested as the most powerful visual elements for indicating directions (Horton, 1993; Pettersson, 2013a) and suggesting movements of writing (Horn, 1998; Tversky et al., 2000).

Although arrows are one of the most commonly used symbols in VIs, it is easy to misuse them. In order to use arrows effectively in VIs, it is suggested to avoid the following situations:

- Avoid locating arrows too far away from the indicated objects, as it will cause confusion (Barker and Fraser, 2004; Amare and Manning, 2016).
- Avoid overstating arrows to make them more excessively visible than the indicated objects (Barker and Fraser, 2004; Amare and Manning, 2016).
- Avoid using too many arrows in one visual display, as it will cause fatigue (Barker and Fraser, 2004; Amare and Manning, 2016).

4.2.3.2 Diagrams

Diagrams are typical informative visual elements, which combine lines and shapes. Diagrams are used to support better understanding of logical, conceptualised and complex information (Amare and Manning, 2016). Figure 4-2 illustrates four types of diagrams. A **cluster** diagram illustrates a bunch of items that are close to each other. A **structure** diagram shows hierarchy or divisions. Lines show connections in cluster diagrams and show divisions in structure diagrams. A **step or stage** diagram presents sequences. A **flow** diagram illustrates a process or workflow. Arrows represent next or causes in a step or stage diagram and represent the direction of flow in a flow diagram (Horn, 1998).

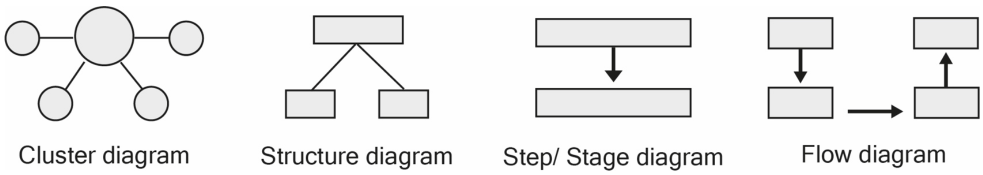


Figure 4-2. Four types of diagrams.

Diagrams are commonly used and critical instructive elements for knowledge presentation (Horn, 1998; Amare and Manning, 2016). Horn (1998) states the functions of diagrams: 1) illustrate complicated relationships; 2) present abstract information in a concrete way; 3) show changes in time; 4) show branching.

Regarding design principles, Amare and Manning (2016) suggest:

A. Diagrams are more effective if they do not contain too many decorations.
B. Critical information should be highlighted in diagrams.
C. Parallel texts are generally effective in diagrams.

4.2.3.3 Illustrations

An illustration is defined as a commercial art that communicates particular information to an audience in a visual representation, which produces the best intellectual engagement in visual communication and problem solving (Horn, 1998; Male, 2017). Illustrations are used to enhance the understanding of corresponding texts and make subjects more attractive (Cheung, 2007; Heller and Chwast, 2008). Illustrations are a vital global visual language, regardless of gender, age and cultural background (Horn, 1998; Male, 2017; Hall, 2011).

Illustrations enhance teaching and learning and are commonly used as VIs in textbooks (Gombrich, 1990; Peeck, 1993; 1994). Although the application of illustrations in textbooks has existed for a long time, illustrations are still often neglected by students and teachers (Reinking, 1986; Peeck, 1993; 1994; Pettersson, 2014).

It is essential to emphasise the responsibilities of illustrations in VIs and to know design principles of illustrations in VIs. By reviewing literature about illustrations for instructions, three functions were identified:

Resemblance – Illustrations that visually represent objects, motions and events. It illustrates an analogue of its equivalent in verbal language. Resemblance is the primary and the most widely used function of illustrations in VIs (Szlichcinski, 1980; Gombrich, 1990; Horn, 1998; Male, 2017; Hall, 2011).

Memory enhancement – Illustrations in VIs facilitates readers' memory. This is in line with the picture superiority effect that has been discussed in Section 2.4.1.1 (Paivio, 1969; Peeck, 1993; Defeyter et al., 2009; Curran and Doyle, 2011).

Communication – Illustrations normally communicates instantly. It generally takes two to three seconds to recognise the contents in an illustration (Paivio, 2013; Avgerinou and Pettersson, 2011).

The pursuit of information is the precondition to expert illustrations in VIs. A great illustration in VIs achieves success by transferring specific information to target audiences appropriately and creatively (Male, 2017). Effective illustrations in VIs are constructed according to some principles (Szlichcinski, 1980). The following illuminates relevant design suggestions and principles for illustrations in VIs.

First, it is suggested that illustrations in VIs should be presented close to the related running texts (Pettersson, 1998; 2013c; 2014). According to Moreno and Mayer (2000), there are two contiguity principles: spatial contiguity principle and temporal contiguity principle. The spatial contiguity principle suggests that illustrations and relevant running texts should be physically close on the same page. The temporal contiguity principle recommends that illustrations and related text segments are temporally synchronised. It is suggested that a considered integration design of texts and illustrations increases effectiveness of VIs (Sadoski and Paivio, 2013).

Second, it is suggested that the realism of illustrations can be reduced, which means the illustration does not need to be exactly the same as the physical objects. However, if the subject matter is abstract, illustrations should make it as concrete as possible (Malamed, 2009). In VIs, illustrations should be presented in a realistic manner, which is different from a piece of artwork (Brouwer, 1995). Third, it is suggested to use global symbols in illustrations for international audiences (Grove, 1989; McAnany and McAnany, 2009). Last, the aesthetics of illustrations have a positive correlation with the effectiveness of VIs (Pettersson, 1998). Therefore, it is suggested that when the effectiveness and legibility requirements are met, illustrations should be designed to be as engaging and pleasant as possible.

4.2.3.4 Typefaces

Typeface choice is important to make sure VIs are legible (Pettersson, 2010; Lonsdale and Lonsdale, 2019). There are serif and sans serif typefaces. A serif typeface has an extra decorative terminal of some strokes (e.g., arms, stems, tails and descenders) while a sans serif typeface has no serifs (*sans* means *without* in French) (Sevilla, 2002; Samara, 2007; Stock-Allen, 2011; Tselentis et al., 2012). Figure 4-3 shows examples of sans serif typefaces and serif typefaces (the terminals highlighted in red are serifs). A serif typeface has contrast in stroke weights, as the major strokes are visually more robust than the non-major strokes (Samara, 2007). A sans serif typeface has less stroke width variables than a serif typeface (Stock-Allen, 2011; Tselentis et al., 2012). In other words, a serif typeface tends to have more variations than a sans serif typeface.

In Chinese typefaces, Songti, Heiti and Kaiti typefaces are generally the most commonly used typefaces in China, which have good legibility and provide a sense of formality (Casas-Tost and Rovira-Esteva, 2018). Both serif and sans serif typefaces originated in the Latin alphabet language (Tselentis et al., 2012) while CCs have similar typefaces (Figure 4-3). Heiti typeface could be identified as a sans serif typeface while Songti typeface and Kaiti typeface are serif typefaces. Songti typeface has a contrast between the vertical and horizontal strokes. The horizontal strokes are thinner and weaker than the vertical strokes in Songti typeface. Kaiti typeface (close to calligraphy) is considered and recommended to be the most suitable typeface for writing VIs in textbooks. Almost all Chinese children start to learn how to write CCs following Kaiti typeface (Zhang, 2011).

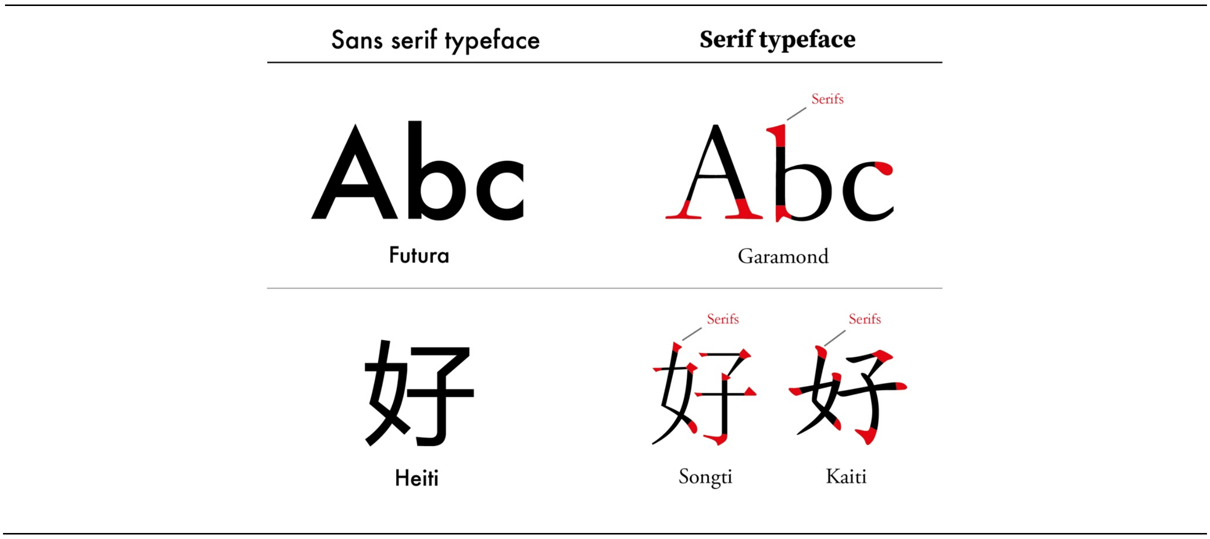


Figure 4-3. Sans serif typefaces and serif typefaces with English and Chinese examples (the red highlighted terminals are serifs).

In VIs, the easiness with which the message can be read is the primary goal over decoration (Sevilla, 2002). Generally, serif typefaces are suggested to be used in body text (McLean, 1980; Schriver, 1997; Sevilla, 2002) and sans serif typefaces are proposed to be used in headings, texts and labels in pictures, diagrams and captions (Simmonds and Reynolds, 1994; Schriver, 1997; Pettersson, 2013a).

Considering the objectives of this study, choosing typefaces in VIs should follow the principles below (Sevilla, 2002; Saltz, 2011; Lonsdale and Lonsdale, 2019):

- To keep VIs concise and legible, no more than two typefaces (maximum three) in documents should be used.
- Typefaces should be chosen to fit with the purpose of VIs.
- Combining different serif typefaces or different sans serif typefaces can cause fatigue and look messy.

4.2.3.5 Colour

Colour is the first information processed in the human brain before any other information cognition (Humphreys and Bruce, 1989). Colour stimulation takes place in the primary visual areas of the human brain (McKeefry and Zeki, 1997). Colour is an essential component and variable of any types of design (Horn, 1998; Samara, 2007; Stone et al., 2008). This section clarifies some relevant terminologies of colour, especially colour appearance terminologies. It also explains why and how colour design facilitates the effectiveness of VIs.

It is important to define colour terminologies, because few people could describe and discuss colour precisely without colour terminologies (Fairchild, 2013). The following terminologies are defined according to Fairchild (2013), Olurinola and Tayo (2015) and Pettersson (2013a). Figure 4-4 shows visual explanations of hue, brightness and saturation.

- **Hue** is a visual sensation that a colour area is distinct from another one (e.g., red, green, yellow and blue).
- **Brightness** is a visual sensation that a colour area transmits less or more light.
- **Saturation** is the colourfulness of a colour area depending on its brightness (Figure 4-4 shows red as an example).

Figure 4-4. Visual explanations of hue, brightness and saturation.

Figure 4-5 show visual explanations of chromatic colour, monochromatic colour and achromatic colour.

- **Chromatic colour** is a group of colours possessing different hues.
- **Monochromatic colour** is a group of colours in a single hue with variations in brightness and saturation (Figure 4-5 shows red as an example).
- **Achromatic colour** is the colours devoid of hue (e.g., white, grey and black).

Figure 4-5. Visual explanations of chromatic colour, monochromatic colour and achromatic colour.

Colour is a powerful technique that has many applications in various education areas (Pettersson, 2013c). Colour has been recognised as an effective tool to motivate learners in their educational experiences (Wichmann et al., 2002). Colour in VIs can be used to enhance memory, increase attention, boost clarity and distinction (Olurinola and Tayo, 2015). Those functions are elaborated next.

Enhance memory – Colour facilitates recall of information (Pettersson, 1998; 2010; 2014; 2019). Colour produces more effective recall than geometrical shapes (Pan, 2010). Colour enhances memory in both texts and pictures (Judy, 2004).

Increase attention – Colour increases learners' attention and perception of visual information (Olurinola and Tayo, 2015; Pettersson, 2015a). Areas of colour are effective tools to emphasise visual elements and important information (Winn, 1993; Mijksenaar, 1997; Pettersson, 2015a; 2019).

Boost clarity and distinction – Colour can be used to make structures clear, group visual elements and facilitate learning processes (Pettersson, 2015a). Colour is able to show differences between diverse types of information and to play down less important messages (Mijksenaar, 1997). Moreover, it could be used to organise similar information (Pettersson, 2019).

For good legibility and use of colour, it is suggested to use a strong colour contrast, i.e., it is better to use dark colours on light backgrounds or light colours on dark backgrounds for figures or texts. Moreover, bold and bright colours are often used for drawing attention (Pettersson, 2010; 2015a). Last, it has been demonstrated that chromatic colours draw more attention than achromatic colours in VIs (Pettersson, 2019). For the colour of illustrations in VIs, it is recommended to use no more than five colours in the same picture (Pettersson, 2019).

Colour coding has been recommended as an effective tool to emphasise visual elements, organise visual information, improve attention and enhance memory in VIs (Peck and Hannafin, 1988; Bradshaw, 2003; Samara, 2007; Pettersson, 2013c; 2015a;). In order to better use colour coding, the following three design principles should be considered:

- Colour coding should not be designed with too many colours synchronously, which increases cognitive load. The maximum limitation for numbers of colour ranges from four to six colours. Pettersson (2010, 2013b) states that an effective application of colour coding for learning should be limited to up to six colours. Dwyer (1972) suggests using no more than four colours on the same page or screen.
- Colour coding should be used in a consistent way to avoid confusion. Inconsistent use of colour coding could reduce the effectiveness of VIs (Pettersson, 2010, 2013b, 2015a).
- Never mix colour coding and decorative colour together, which bring confusion and misunderstanding (Pettersson, 2010; 2014).

4.2.4 Summary

Humans have short-term and long-term memory (Atkinson and Shiffrin, 1971; Mcleod, 2010; Diamond, 2013). The dual coding theory (Paivio, 1986; 2013; Clark and Paivio, 1991) suggests that people have better memory, especially long-term memory, if the information is presented using text (verbal-coding) and pictures (visual-coding) together. The picture superiority effect (Paivio, 1986; Defeyter et al., 2009; Pettersson, 2014) proposes that pictures are easier to remember than texts.

The cognitive load theory (Chandler and Sweller, 1991) suggests that effective VIs benefit learning by directing cognitive information. If diagrams or illustrations require learners to split their attention among various sources of information, they are less effective. The cognitive load theory does not suggest presenting various sources of information separately, which would split readers' attention and reduce the effectiveness of processing information (Ward and Sweller, 1990; Sweller and Chandler, 1991; Ayres and Sweller, 2005). In other words, pictures, texts, shapes and other design elements should be integrated as a meaningful whole rather than a number of individuals

(Pettersson, 2014). Split-attention effect also suggests that removing redundant information is a useful method to improve effectiveness of VIs (Chandler and Sweller, 1992).

VIs present information in an effective way for a specific goal (Burke and Wilber, 1998; Pettersson, 1998; 2014; Simlinger, 2007). According to the instructional goals in this study, related general visual perception principles were reviewed, including simplicity principle, similarity principle, focal point principle and contrast principle (Chang et al., 2002; Lipton, 2011; Ali and Peebles, 2013; Pettersson, 2014; Lonsdale and Lonsdale, 2019).

Specific design elements for instructional goals were also reviewed, including arrows, diagrams, illustrations, typefaces and colour. Arrows are typical instructional design elements for instructing directions and movements (Horton, 1993; Horn, 1998; Tversky et al., 2000; Pettersson, 2013a), which could be an effective approach for instructing writing SRs in an accurate stroke direction.

Diagrams are generally used for showing relationships between concepts (Amare and Manning, 2016), including cluster diagrams, structure diagrams, step diagrams and flow diagrams (Horn, 1998), which could be applied for instructing relationships between SRs and CCs.

Illustrations are commonly used for enhancing understanding of corresponding texts (Cheung, 2007; Heller and Chwast, 2008), which could be a useful method for instructing meanings and shapes of SRs.

In terms of typefaces, Songti, Heiti and Kaiti typefaces are the most commonly used typefaces in China (Casas-Tost and Rovira-Esteva, 2018). Kaiti is recommended as a suitable typeface in writing VIs (Zhang, 2011).

Colour is a crucial variable in different design elements (Horn, 1998; Samara, 2007; Stone et al., 2008) and an important approach for enhancing memory performance (Humphreys and Bruce, 1989; McKeefry and Zeki, 1997; Pettersson, 2014; 2019). Therefore, colour as an essential visual element should be given enough attention in VIs. Colour could be considered as one of the methods to improve learning and memory of SRs.

4.3 Visual survey

To explore existing cases that used VIs for enhancing learning CCs or SRs, a visual survey was conducted. The survey included search, selection, depiction and analysis, and it firstly helped to check how the VIs align with the theories and principles of design. Moreover, this survey demonstrated what can be learnt from the existing cases and provided materials for the first experimental study (reported in Section 5.2).

4.3.1 Methods

The visual survey explored the diversity of existing cases. Due to the limitation of VIs for learning Chinese SRs by non-specialist beginners, the scope of the visual survey was expanded as follows.

Choosing existing VIs was not restricted to:

1) VIs for learning CCs or SRs. The scope covered components, 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.

A total of 35 cases were explored in this study. Appendix II shows figure examples of the 35 cases. They were given numbers from No. 1 to No. 35, according to their years of first publication or release. Among the 35 cases, 31 cases (excluding cases No. 11, 15, 21, 34) had VIs for Reading & Memorising CCs or SRs, 17[16] (49%) cases for writing CCs. In the 17 cases, 12[17] (37%) cases had both VIs for Reading & Memorising and writing CCs or SRs.

This research explored the effectiveness of VIs for learning SRs. Therefore, the photos for decorations were not included in this study. The photos in cases No. 17 and 18 that were discussed in the visual survey described the meaning of CCs. Findings of the visual survey are explained in the next section.

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[16] The 17 cases are No. 3, 4, 6, 7, 9, 10, 11, 15, 19, 21, 23, 28, 30, 31, 33, 34, and 35.

[17] The 12 cases are No. 3, 4, 6, 7, 9, 10, 19, 23, 28, 30, 33 and 35.

4.3.2 Findings

The two main classifications are VIs for Reading & Memorising and VIs for writing (Table 4-2). In the VIs for Reading & Memorising, five main instructional functions existed in the 31 cases. The five functions were to resemble meanings, imitate shapes, highlight positions, display hierarchical relationships, and display connection relationships. Accordingly, the instructional functions had a one-to-one correspondence with four instructional goals (refers to Table 4-2). To achieve the goals, images, instructional colour, shapes and diagrams were used in the 31 cases.

In the VIs for writing, three main instructional functions were to display stroke order and stroke directions, and standardise positions of strokes, which corresponded to the three goals (refers to Table 4-2) for writing CCs and SRs. Colour, numbers, arrows and line guides were used in the 17 cases.

Table 4-2. VIs in the 35 existing cases for learning CCs and SRs.

VIs	Instructional functions	Goals	Elements
Reading & Memorising	To resemble meanings	Meanings	Images
	To imitate shapes	Shapes	
	To highlight positions	Positions	Instructional colour
			Shapes
	To display hierarchical relationships	Relationships between SRs and CCs	Diagrams
	To display connection relationships		
Writing	To display stroke order	Stroke order	Colour
			Numbers
	To display stroke directions	Stroke directions	Arrows
	To standardise positions of strokes	Stroke positions	Line guides

Note: CC = Chinese Character; SR = Semantic Radical; VI = Visual Instruction

These design elements were presented and combined with SRs and CCs in various ways and would be further described and analysed. In order to present design elements and variables clearly and consistently, SR Mouth and related CCs were taken as an example when SRs or CCs were needed for presenting.

Some cases used more than one type of design elements. For example, case No. 17 (Appendix II) used images, diagrams and colour coding. These cases were counted once in each type of element. That is to say, case No. 17 was counted three times while checking the quantities of each element in the existing cases (once for image cases, once for diagram cases and once for colour coding cases). Similarly, some cases used design elements with more than one type of variables. For example, case No. 7 had some illustrations in chromatic colour, and other illustrations in achromatic colour. Therefore, case No. 7 was counted once when counting chromatic colour illustrations. Case No. 7 was counted another time while counting achromatic colour illustrations.

4.3.2.1 Design elements for Reading & Memorising CCs (or SRs) in the existing cases

Table 4-3 lists the four design elements of VIs for Reading & Memorising in the 31 cases. In the 31 cases, 26 cases used images, seven cases used diagrams, three cases used shapes and six cases used instructional colour.

Table 4-3. Design elements of VIs for Reading & Memorising in the 31 existing cases.

Design Elements (Cases number)	**Cases** (Appendix II)
Images (26)	Case No. 1, 2, 3, 5, 6, 7, 8, 9, 10, 13, 14, 17, 18, 19, 22, 23, 24, 25, 27, 28, 29, 30, 31, 32, 33, 35
Diagrams (7)	Case No. 14, 16, 17, 19, 20, 25, 26
Shapes (3)	Case No. 2, 4, 9
Instructional colour (6)	Case No. 12, 14, 16, 17, 20, 25

Table 4-4 shows the quantities of each variable of the four design elements and the corresponding cases, which will not be repeated. Figure 4-6 shows the visual variables of images separately in the 26 cases. Figure 4-7 displays the visual variables of diagrams respectively in the seven cases. Figure 4-8 illustrates the visual variables of shapes separately in the three cases and visual variables of instructional colours respectively in the six cases. They were all designed with SR Mouth as an example.

Table 4-4. Design elements and variables of VIs for Reading & Memorising in the 31 existing cases.

Elements	**Visual types**	**Variables**		**Cases** (Appendix II)	
Images 26 cases	Illustrations	Colour	Chromatic colour	13 cases	No. 7, 8, 13, 14, 17, 19, 22, 23, 24, 25, 27, 29, 35
			Monochromatic colour	3 cases	No. 31, 32, 33
			Achromatic colour	10 cases	No. 1, 2, 3, 5, 6, 7, 9, 10, 28, 30
		Outlines & colours	Colour areas only	12 cases	No. 7, 8, 13, 14, 17, 19, 22, 23, 24, 27, 31, 32
			Outlines only	6 cases	No. 3, 6, 9, 10, 28, 30
			Colour areas and outlines	8 cases	No. 1, 2, 5, 17, 25, 29, 33, 35
		Content styles	Modern style	23 cases	No. 1, 2, 3, 5, 6, 7, 8, 9, 10, 14, 19, 22, 23, 24, 25, 27, 28, 29, 30, 31, 32, 33, 35
			Traditional Chinese style	3 cases	No. 1, 8, 13
		Technique styles	Vector-drawing style	12 cases	No. 2, 7, 8, 14, 17, 19, 22, 23, 24, 27, 31, 32
			Hand-drawing style	14 cases	No. 1, 3, 5, 6, 9, 10, 13, 17,25, 28, 29, 30, 33, 35
		Combinations	Integrated& Imitation	9 cases	No. 6, 7, 8, 22, 23, 24, 25, 27, 28,
			Next & Imitation	9 cases	No. 1, 2, 3, 5, 10, 14, 30, 31, 32
			Next & Description	8 cases	No. 6, 9, 13, 19, 25, 29, 33, 35
		Size contrasts	Similar size of illustrations and CCs or SRs	15 cases	No. 6, 7, 9, 10, 22, 23, 24, 27, 28, 29, 30, 31, 32, 33, 35
			Big illustrations and small CCs or SRs	11 cases	No. 1, 2, 3, 5, 6, 8, 13, 14, 19, 25, 27
	Photos	None		2 cases	No. 17, 18
Diagrams 7 cases	Structure diagrams	Colour	Colour coding	1 case	No. 20
			Colour highlights	1 case	No. 25
	Cluster diagrams		Achromatic colour	1 case	No. 26
			Colour highlights	3 cases	No. 14, 16, 19
			Colour coding	1 case	No. 17
Shapes 3 cases	Square	Outline	Outline	1 case	No. 4
			Black colour highlights	2 cases	No. 2, 9
Instructional Colours 6 cases	Colour highlight	None	Colour highlights	2 cases	No. 14, 16
	Colour coding	Different coding	Diagrams are coded with colour	2 cases	No. 17, 20
			SRs are codes with colour	1 case	No. 12
			Illustrations are coded with colour	1 case	No. 25

Note: CC = Chinese Character; SR = Semantic Radical

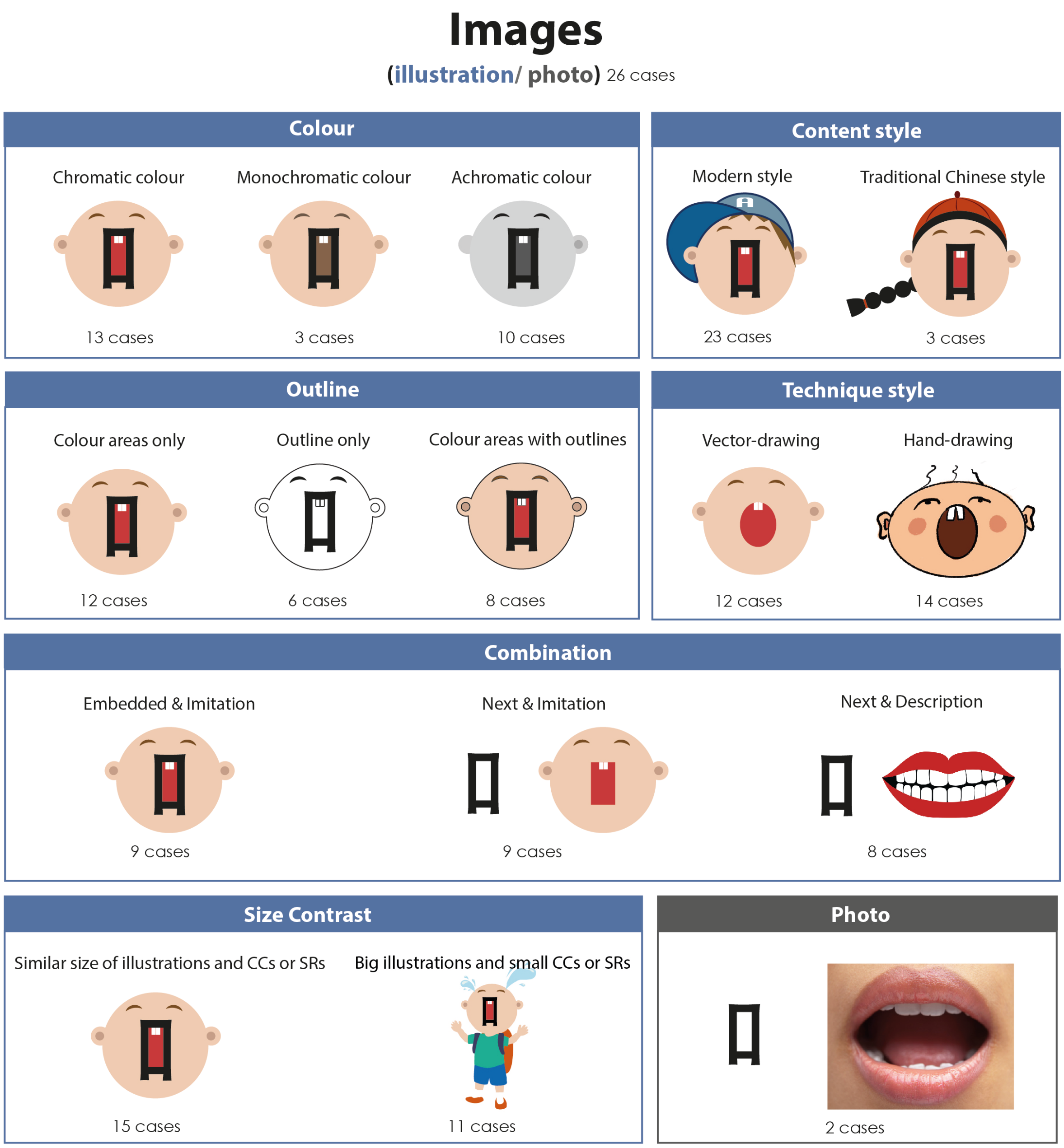
In terms of the images, the identifications of content and technique styles, the counting of outlines & colours and the definitions of combinations will be explained.

For content styles, in the 26 illustrations cases, most cases (23 cases) had illustrations drawn in modern styles while a few cases (three cases) had illustrations drawn in traditional Chinese styles. Case No. 1 had combined modern and traditional styles. The traditional Chinese styles were identified by traditional Chinese elements (e.g., cases No. 1 and No. 8 had traditional Chinese costume) and traditional Chinese painting (e.g., case No. 13).

For technique styles, there was not much difference in the number of cases that had hand-drawing style illustrations (14 cases) and vector-drawing style illustrations (12 cases). The hand-drawing style was identified by irregular edges and sketchy shapes (White, 2018). The vector-drawing style was identified by defined edges and precise curves (White, 2018).

In regard to the outlines & colours of illustrations, 12 cases used colour areas only; six cases used outlines only; and eight cases used both colour areas and outlines. If counted the cases in two types, it can be concluded that 14 cases had illustrations with outlines and 12 cases had illustrations without outlines.

Regarding the combinations between the illustrations and CCs or SRs, nine cases had the Integrated & Imitation combination that described the illustrations integrated with CCs or SRs. Eight cases had the Next & Imitation combination that described the illustrations presented next to CCs or SRs. For the above two combinations, the illustrations imitated the shapes of CCs or SRs, and the illustrations also visualised the meanings of CCs or SRs. Eight cases had the Next & Description combination that described the illustrations displayed next to CCs or SRs. The illustrations described the meanings of CCs or SRs rather than the imitated shapes of CCs or SRs.



Note: CC = Chinese Character; SR = Semantic Radical

Figure 4-6. Visual variables of images in the 26 cases.

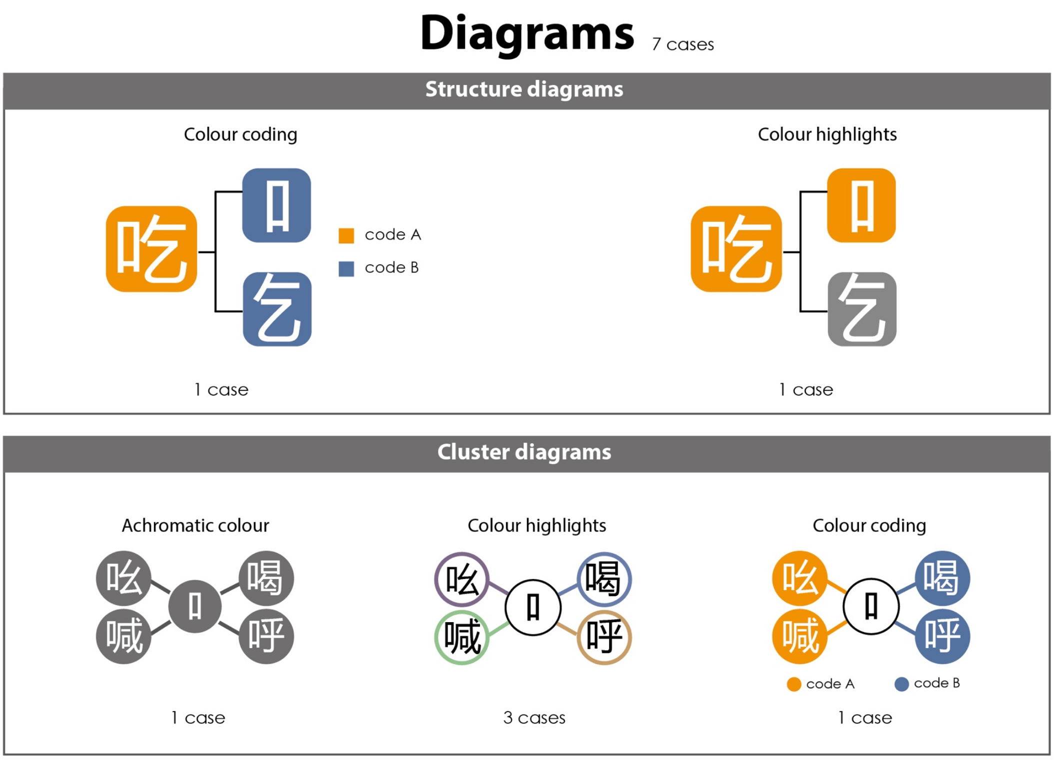
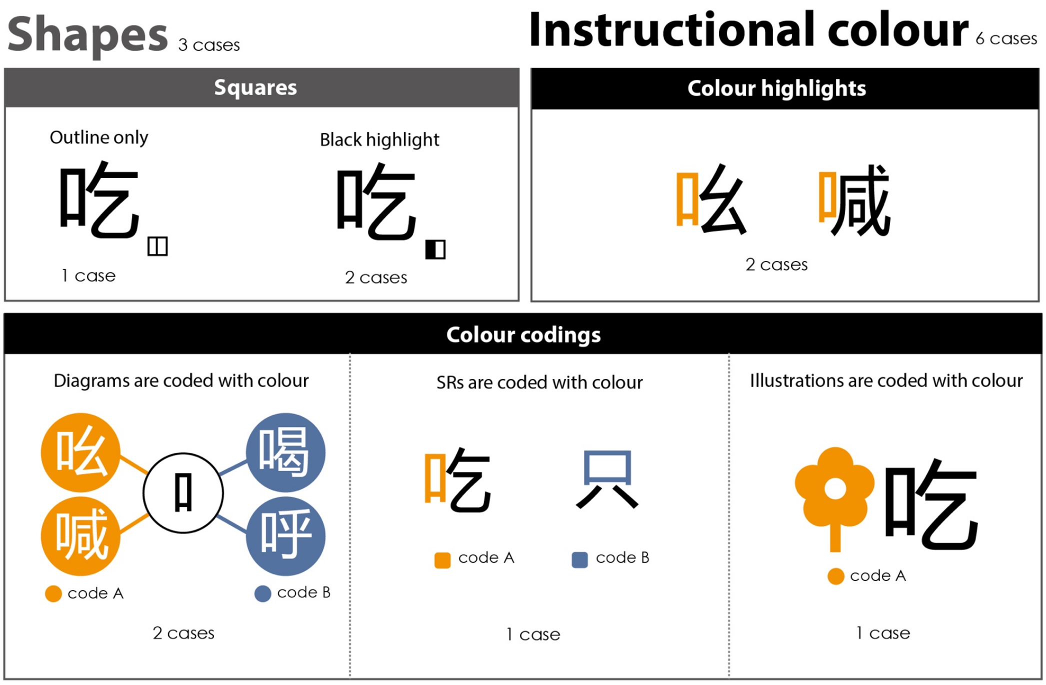


Figure 4-7. Visual variables of diagrams in the seven cases.



Note: SR = Semantic Radical

Figure 4-8. Visual variables of shapes and visual variables of instructional colour.

4.3.2.2 Design elements for writing CCs (or SRs) in the existing cases

In the 17 cases, VIs for writing had two different presentations. Thirteen cases used stroke-by-stroke presentation and five cases used all-in-one presentation. Case No. 9 had both two types of presentations. In these two presentations, four design elements were used in the writing VIs: colours (11 cases), line guides (nine cases), numbers (four cases) and arrows (five cases). Table 4-5 lists the corresponding cases for the two presentations and the four design elements. Table 4-6 shows the quantities of different variables in the 17 cases of the four design elements and are not repeated.

Table 4-5. Design elements and variables of VIs for writing in the 17 cases.

Presentations (number of cases)	**Cases** (Appendix II)
Stroke-by-stroke presentation (13)	Cases No. 3, 4, 6 ,7, 9, 10, 11, 15, 28, 30, 31, 34, 35
All-in-one presentation (5)	Cases No. 9, 19, 21, 23, 33
Design elements (number of cases)	
Colours (11)	Case No. 6, 7, 9, 15, 19, 21, 23, 31, 33, 34, 35
Line guides (9)	Case No. 7, 9, 10, 19, 21, 23, 31, 33, 34
Numbers (4)	Case No. 9, 21, 23, 33
Arrows (5)	Case No. 9, 19, 21, 23, 33

Table 4-6. Design elements and variables of VIs for writing in the 17 cases.

Design Elements	**Variables**		**Cases**	
Colour 11 cases	Colour types	Achromatic colour hints	8 cases	Case No. 6, 9, 19, 21, 23, 31,33, 34
		Chromatic colour hints	3 cases	Case No. 7, 15, 35
Line guides 9 cases	Styles	Style 1	4 cases	Case No. 7, 10, 23, 19
		Style 2	4 cases	Case No. 9, 31, 33, 21
		Style 3	1 case	Case No. 34
Numbers 4 cases	Position	Inside	1 case	Case No. 23,
		Outside	3 cases	Case No. 9, 21, 33
	Colour	Chromatic colour	1 case	Case No. 21
		Achromatic colour	3 cases	Case No. 9, 23, 33
Arrows 5 cases	Position	Inside	3 cases	Case No. 9, 19, 23
		Outside	2 cases	Case No. 21, 33
	Colour	Chromatic colour	3 cases	Case No. 19, 21, 33
		Achromatic colour	2 cases	Case No. 9, 23

Figure 4-9 shows the visual examples of the two presentations and variables of the four elements with the CC Mouth or a single stroke as examples. Colour was used as hints for instructing stroke order. Line guides were used to show and standardise positions of strokes in squares. Line guides style 1 and style 2 had cross-shape lines, while style 3 had grid lines. The line guides style 1 had a cross-shape (+) with two diagonal lines, while style 2 had the cross-shape (+) only. Numbers were used for indicating stroke order. The positions between numbers and strokes and the colour of numbers were different. Arrows were applied for indicating stroke directions.

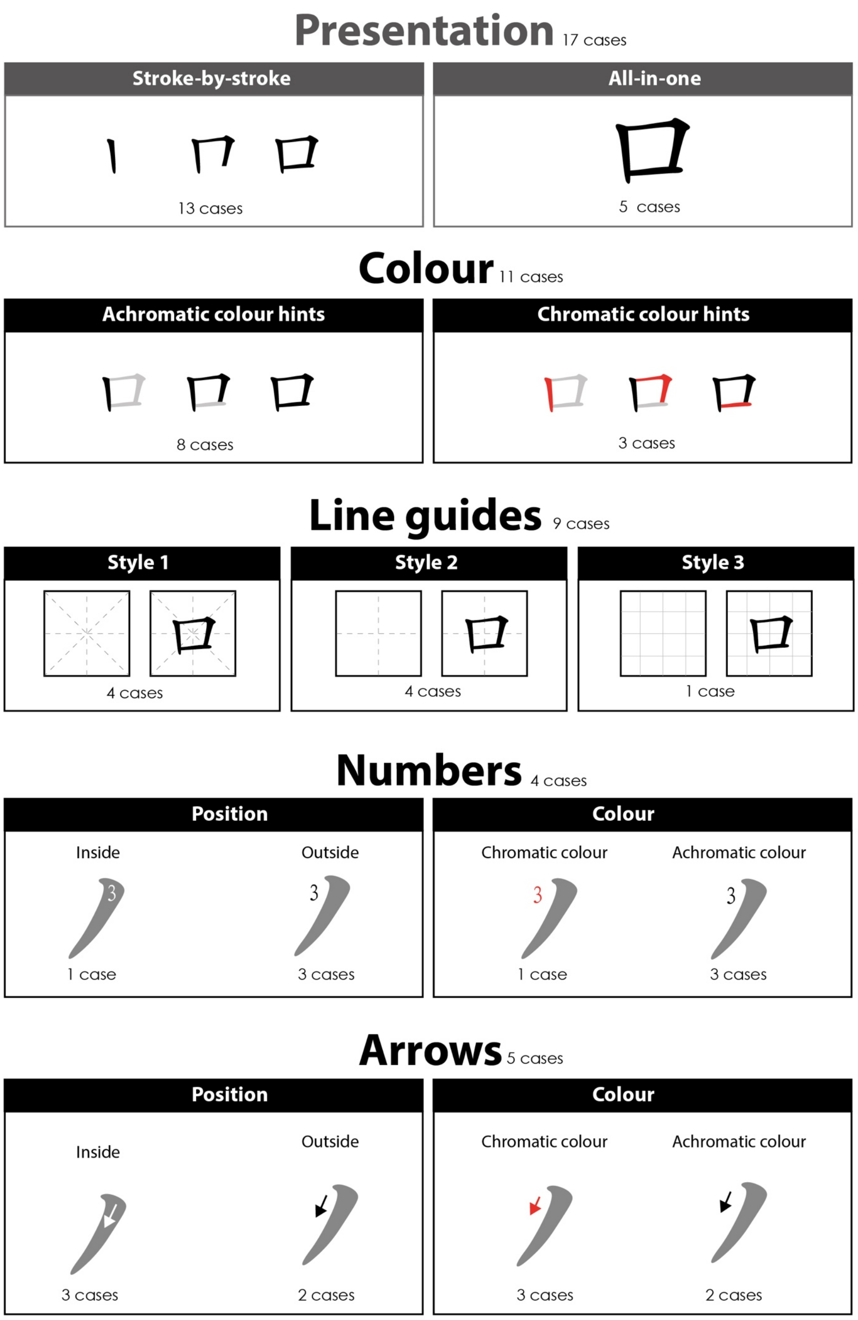


Figure 4-9. Variables of VIs for writing CCs or SRs in the 17 existing cases.

4.3.2.3 Typefaces used in the existing cases

Apart from case No. 29 and No. 32 that used handwritten texts, three typefaces (Songti, Kaiti and Heiti) were used in the existing cases. Table 4-7 shows the quantities and related cases of different typefaces used in the VIs for Reading & Memorising and VIs for writing, which will not be repeated. Figure 4-10 shows the three different typefaces with the CC Mouth as an example.

Table 4-7. Typefaces of the VIs in the existing cases.

VIs	Typeface	Cases	
Reading & Memorising	Songti	8 cases	Case No. 6, 7, 10, 11, 12, 18, 30, 33
	Kaiti	13 cases	Case No. 3, 4, 5, 9, 13, 17, 19, 20, 23, 25, 26, 28, 35
	Heiti	10 cases	Case No. 1, 2, 8, 12, 14, 16, 20, 22, 24, 27
Writing	Songti	2 case	Case No. 7, 33
	Kaiti	14 cases	Case No. 3, 4, 6, 9, 10, 11, 15, 19, 21, 23, 28, 30, 31,35
	Heiti	1 case	Case No. 34

Note: VI = Visual Instructions

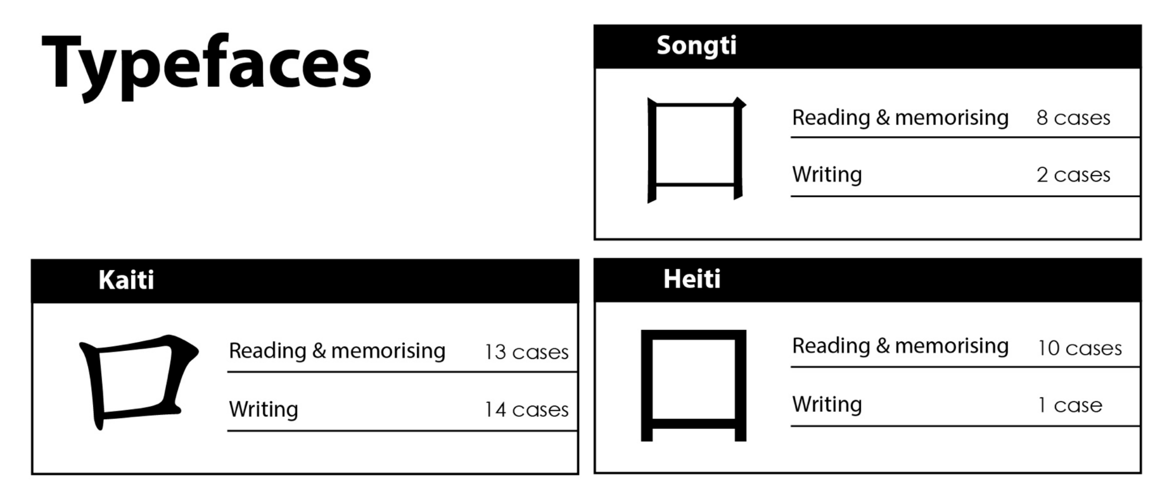


Figure 4-10. Typefaces of the VIs in the existing cases.

In summary, 35 existing cases were investigated in the visual survey, including VIs for Reading & Memorising (31 cases) and VIs for writing (17 cases). Different design elements in the 35 cases were described and categorised with different variables. The quantities of the existing cases of individual variables were counted in the visual survey. For the VIs for Reading & Memorising, images, diagrams, shapes and instructional colours were used. For the VIs for writing CCs or SRs, two presentations (i.e., stroke-by-stroke presentation and all-in-one presentation) and four visual elements (i.e., colour, line guides, numbers and arrows) were used. In terms of typefaces, Songti, Kaiti and Heiti were used.

The literature review put forward general design principles and specific principles of particular design elements (e.g., illustrations, colours and arrows). The visual survey described and summed up the usage of design elements with diverse variables in the 35 existing cases. The consistency between the visual perception principles and the visual elements in the visual survey will be discussed in the next section.

4.4 Discussion and conclusions

Cognitive theories provide two main suggestions. First, the **dual coding theory** (Paivio, 2013; 1986; Clark and Paivio, 1991) suggests that people have a better memory when provided with both pictures and texts at the same time. Moreover, it also suggests that pictures facilitate memory (Peeck, 1993; Defeyter et al., 2009; Curran and Doyle, 2011). However, the suggestion that pictures enhance memory is relatively broad, as the theory does not clearly point out what kind of pictures facilitate memory. The findings of the visual survey show that the presentations of illustrations are very diverse, especially presenting with CCs or SRs.

Second, the **cognitive load theory** (Miller, 1956; Kahneman, 1973; Bower, 1975; Chandler and Sweller, 1991) suggests that integrating different sources of information as a meaningful whole reduces memory load. On the other hand, presenting various sources of information separately increases memory load. The suggestion is consistent with the simplicity principle, which suggests that the simplification of design enhances visual perception and facilitates memory (Lipton, 2011). The consistency between the suggestions from the literature review and visual elements in the visual survey will be discussed as follows.

Images, especially illustrations, were widely used in the 35 existing cases for enhancing learning SRs and CCs, which was aligned with the dual coding theory and the picture superiority effect (Paivio, 1986; 2013; Clark and Paivio, 1991; Defeyter et al., 2009; Pettersson, 2014).

The results of the visual survey showed that the illustrations in the 26 cases had diverse presentations. First, some existing cases had illustrations with excessive and unnecessary visual details, which was against the simplicity principle. For example, 14 cases used hand-drawing style illustrations, which had irregular edges and sketchy shapes (White, 2018). For an instructional purpose, excessive and pointless details were against the simplicity principle, and therefore will lead to an increase in memory load and have a negative impact on the effectiveness of VIs.

Second, integrating SRs into illustrations is a novel and theoretically suggested approach, and its effect has not been proved yet. In terms of the combinations of illustrations and CCs (or SRs) in the existing cases, 17 cases had illustrations next to CCs (or SRs) and nine cases had illustration integrated with CCs (or SRs). The cognitive load theory (Kahneman, 1973; Bower, 1975; Chandler and Sweller, 1991) suggests that integrating different elements as a meaningful whole is easier to remember than presenting them separately. The results of the visual survey showed that nine of the 26 illustration cases attempted to integrate SRs or CCs into illustrations.

The remaining cases still followed the standard presentation approach. Although it was suggested that illustrations should be presented closely to texts in VIs (Pettersson, 1998; 2013c; 2014), the effect of integrating SRs into illustrations has not been proved yet. Moreover, none of the previous studies (details in Section 3.2.3) tested the effect of integrating SRs (or CCs) into illustrations.

Third, some cases had VIs following the focal point principle, while the others neglected this principle. The focal point principle suggests that colour or size highlighted places draw more attention than unhighlighted places in VIs (Chang et al., 2002; Lipton, 2011; Ali and Peebles, 2013; Pettersson, 2014; Lonsdale and Lonsdale, 2019). Pettersson (2019) stated that chromatic colour draws more attention than achromatic colours in VIs. In regard to the colours of illustrations, 13 cases used chromatic colour, 10 cases used achromatic colour and three cases used monochromatic colour. The effectiveness of monochromatic colour has not been proved yet. In terms of the size contrast, 11 cases had small CCs (or SRs) and big illustrations, which emphasised the illustrations rather than CCs (or SRs). The instructional illustrations should assist in explaining the information of CCs (or SRs) rather than drawing more attention to themselves. The combinations of illustrations and SRs (or CCs) needed more research.

Lastly, in the 26 illustration cases, most cases (23 cases) used modern style illustrations, while a few cases (three cases) used traditional Chinese style illustrations. This is in line with the statement that global visual elements should be used for international audiences (Grove, 1989; McAnany and McAnany, 2009), which is suitable for the purpose of this study. Cases No. 1 and No. 8 used illustrations in a combination of traditional Chinese and modern style. It is understandable that using traditional Chinese style illustrations might help understand the Chinese culture better. However, it might have a negative impact on the effectiveness of learning and memory. This was further explored with participants in Study 1 in Section 5.2.

The **diagrams**, **shapes** and **colours** in the VIs for Reading & Memorising had a small number of cases in the 31 existing cases. Diagrams were used in seven cases to show hierarchies and connections between CCs and SRs. Diagrams were recommended in the literature review as an effective visual form to present relationships (Horn, 1998).

Square shapes were used in three cases for abstracting structures of CCs and highlighting positions of SRs. It is suggested that applying chromatic colours produces more effective memory than using geometrical shapes only (Pan, 2010). In the three cases, none of them had square shapes in chromatic colour. Therefore, square shapes in chromatic colour can be further explored.

In regard to **colours** (excluding decorative colour in illustrations), six cases used colours with instructional functions for Reading & Memorising CCs or SRs; and 11 cases had colour with instructional functions for writing CCs. Moreover, some numbers and arrows in writing VIs had colours with a highlighting function. These colour applications mainly made use of the function of enhancing memory (Humphreys and Bruce, 1989; McKeefry and Zeki, 1997; Pettersson, 1998; 2014; 2019) and increasing attention (Mijksenaar, 1997; Olurinola and Tayo, 2015). To be more specific, four cases used colour coding, and it was suggested that colour coding was an effective tool to organise visual information and enhance memory in VIs (Peck and Hannafin, 1988; Bradshaw, 2003; Samara, 2007; Pettersson, 2013c; 2015). However, the four colour coding applications had different instructional goals, and they were combined with different visual elements, such as colour coding and diagrams (case No. 20). The effect of colour coding for learning SRs needs to be further explored.

Although writing CCs (or SRs) following accurate stroke directions is important for the acquisition of CCs (Jaganathan and Lee, 2014) and **arrows** are suggested as a practical element for indicating directions (Horton, 1993; Pettersson, 2013a) and movement (Horn, 1998; Tversky et al., 2000), only five cases used arrows in the 17 cases (VIs for writing).

In terms of **typefaces**, using Kaiti typeface for writing VIs was suggested by Zhang (2011) and teachers in the interview in Section 3.3. Kaiti typeface is also the most popular typeface (14 of 17 cases) in the VIs for writing. Hence, Kaiti typeface was used when developing the VIs for writing SRs in this study.

However, for Reading & Memorising, sans serif typefaces have less decorations (Sevilla, 2002; Samara, 2007; Stock-Allen, 2011; Tselentis et al., 2012) and they are suggested to be used in headings and captions (Simmonds and Reynolds, 1994; Schriver, 1997; Pettersson, 2013a). Heiti is a sans serif typeface while Songti and Kaiti are serif typefaces. In the existing cases, 13 cases used Kaiti, 10 cases used Heiti and eight cases used Songti. There was no big difference among the numbers of the three typefaces in the existing cases. Hence, the choice of typefaces in the VIs for Reading & Memorising was further investigated in Study 1 in Section 5.2.

The design elements and variables in the VIs for Reading & Memorising are diverse. The learning goals are clear. However, the effectiveness of some novel approaches has not been proved yet, for example, the effectiveness of integrating SRs into illustrations. Some design suggestions are vague, especially when it comes to VIs for enhancing learning CCs, for example, the effectiveness of combining colour coding and illustrations. In order to narrow down the wide range of various design elements and variables, opinions about the effectiveness of design elements and variables were further explored in Study 1, since understanding the viewpoints of learners is critical to evaluate the effectiveness of VIs (Shannon and Weaver, 1963; Doblin, 1980). In terms of the VIs for writing SRs, the design elements are limited, and the design suggestions in the literature review are clear. Therefore, the next step of exploring VIs for writing SRs (Chapter 6) is to develop prototypes and test the effectiveness, rather than further explore the variables.

5 Study of VIs for Reading & Memorising SRs

5.1 Introduction

The study in Chapter 5 aimed to investigate what kind of VIs enhanced memorising SRs and how they enhanced memorising SRs. This study was based on the findings in Chapters 3 and 4. The discussion in Chapter 3 showed a demand and a limited number of research about investigating the effectiveness of VIs for Reading & Memorising SRs by non-specialist beginners. However, the discussion in Chapter 4 showed that existing cases had a variety of design elements and variables. The literature review in Section 4.2 also indicated that different visual design elements had specific effects on learning and memorising.

The study of VIs for Reading & Memorising SRs includes Study 1 (existing design), Study 2 (design development) and Study 3 (new design). A total of 70 participants took part in the study, including 30 participants in Study 1, 10 participants in Study 2 and 30 participants in Study 3. Study 1 aimed to examine the potential effectiveness of existing designs and narrow down the wide range of design elements and variables in the existing designs. Study 2 aimed to develop design prototypes for enhancing memorising SRs. Based on the results of the Study 1, the prototypes were developed and improved by conducting iterative usability tests. Study 3 aimed to examine the effectiveness of the new design for enhancing memorising Chinese SRs. The measurement of the effectiveness was the per cent accuracy, the answering speed in memory tests and the participants' opinions after the memory tests.

5.2 Study 1: a quasi-experimental study on existing design for Reading & Memorising SRs

The findings of the visual survey in Section 4.3 showed that illustrations, diagrams, squares and instructional colours were the four types of VIs used in the existing cases. Therefore, aiming to preliminarily investigate the effectiveness of the four types of VIs in the existing cases, a learn-and-test task was conducted with six cases. The reasons for selecting the six cases out of the 31 cases will be explained in Section 5.2.1.2.

The results of the visual survey also showed that the existing designs had many variables. In order to narrow down the broad range of variables, a ranking task was conducted after the learn-and-test task. The learn-and-test task was conducted firstly because it provided learning experience to participants, which benefited to the following ranking task.

5.2.1 Methods

5.2.1.1 Participants

A total of 30 participants were recruited. The age range was from 19 to 46, with a mean age of 29. They were ab initio beginners regarding CCs and SRs, 21 were female and nine were male. The participants consisted of 15 British, three Brazilians, two Mexicans, two Italians, one Malaysian, one Spanish, one Motswana, one Indonesian, one Dutch, one American, one Irish and one Saudi Arabian. All the participants from the 12 different nationalities have studied and/or lived in the UK. They were named from S1P1 to S1P30.

5.2.1.2 Materials

Materials used in Study 1 were selected from the 31 existing cases (refers to Section 4.3 and Appendix II) which have VIs for Reading & Memorising SRs. Six cases were tested in the learn-and-test task and the 31 cases were used as visual examples in the ranking task. The selection of the six cases for the learn-and-test task will be explained as follows.

Materials used in the learn-and-test task: the task aimed to initially examine the effectiveness of VIs in existing cases. The selected cases used in the task needed to meet four criteria. First, the selected cases have VIs for instructing SRs rather than CCs. Second, they have VIs for instructing one SR per page rather than a collection of SRs. Third, they have VIs instructing the complete knowledge of SRs, including meanings, shapes and positions in related CCs of SRs. Fourth, they do not highlight phonetic information (e.g., tones). Table 5-1 shows the criteria for selecting the cases that were used in the learn-and-test task. Six cases were selected used in the learn-and-test task: Material A (No. 24), Material B (No. 6), Material C (No. 12), Material D (No. 2), Material E (No. 25) and Material F (No. 16). Table 5-2 shows the details of the different VIs of the six materials with their introduced SRs, which will not be repeated. Figure 5-1 shows the scaled-down version of the six materials for the illustration purpose (the original materials were given in A4 size).

Table 5-1. The criteria for selecting the cases that were used in the learn-and-test task.

Criteria	**Cases**															
1. Cases that have VIs for instructing SRs rather than CCs.	1	2	3	4	5	6	7	8	9	10	12	13	14	16	17	
	X		X		X			X		X		X	X			
	18	19	20	22	23	24	25	26	27	28	29	30	31	32	33	35
		X		X	X				X	X	X	X	X	X	X	X
2. Cases that have VIs for instructing one SR per page rather than a collection of SRs.		2		4		6	7		9		12			16	17	
				X					X						X	
	18		20			24	25	26								
								X								
3. Cases that have VIs for instructing the complete knowledge of SRs.		2				6	7				12			16		
							X									
	18		20			24	25									
	X															
4. Cases that do not highlight phonetic information.		2				6					12			16		
			20			24	25									
			X													

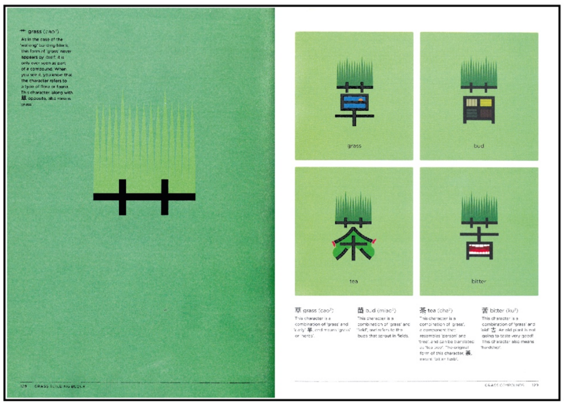
Note: CC = Chinese Characters; SR = Semantic Radical; X = Do not meet the criterion

The selected cases need to meet all the criteria. Therefore, cases that do not meet the previous criteria are not listed in latter rows. For example, case No. 1 does not meet the first criterion, so it is not listed in the second row.

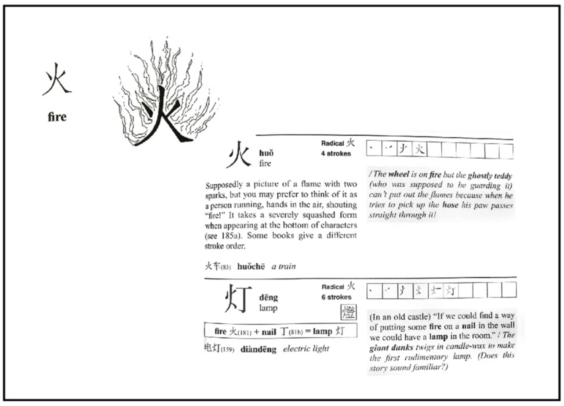
Table 5-2. The six materials and the related six SRs and VIs tested in the learn-and-test task.

Materials (Case No. in Appendix II)	**SRs** (Meaning: stroke number) (Typeface)	**VIs with different variables**	
A (Case No. 24)	艹 (Grass: 3) (Heiti)	Illustrations	• Chromatic colour • Colour areas only • Vector-drawing style • Integrated & imitation • Similar size of SRs and illustrations
B (Case No. 6)	火 (Fire: 4) (Songti)	Illustrations	• Achromatic colour • Outline only • Hand-drawing style • Integrated & imitation • Similar size of SRs and illustrations
C (Case No. 12)	氵 (Water:3) (Heiti)	Instructional colours	• Colour coding • Big CCs and SRs
D (Case No. 2)	心 (Heart: 4) (Heiti)	Illustrations	• Achromatic colour • Colour areas only • Vector-drawing style • Next & Imitation • Small SRs and big illustrations
		Squares	• Square with black highlights
E (Case No. 25)	扌 (Hand: 3) (Kaiti)	Illustrations	• Chromatic colour • Colour areas with outlines • Hand-drawing style • Integrated & imitation • small SRs and big illustrations
		diagrams	• Colour highlighted structure diagrams
F (Case No. 16)	饣 (Food: 3) (Heiti)	Instructional colours	• Colour highlight SRs • Small SRs
		diagrams	• Achromatic colour cluster diagrams

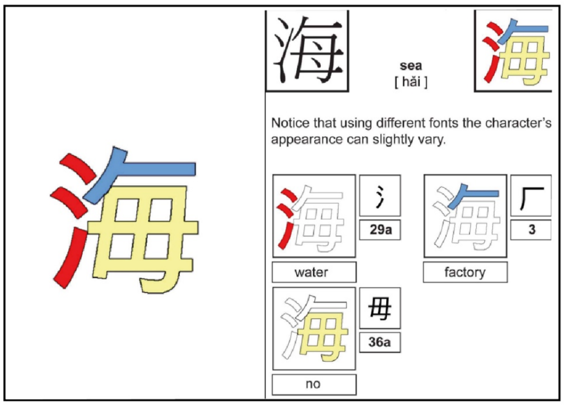
Note: CC = Chinese Character; SR = Semantic Radical; VI = Visual Instruction



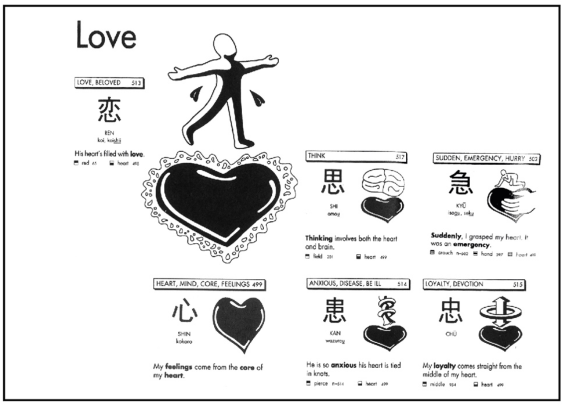
A SR Grass
(Hsueh, 2014)



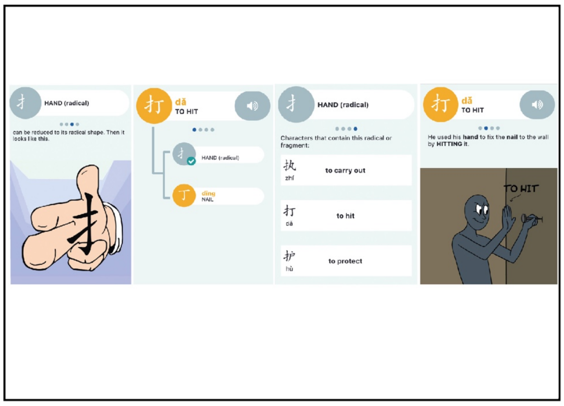
B SR Fire
(Matthews and Matthews, 2007)



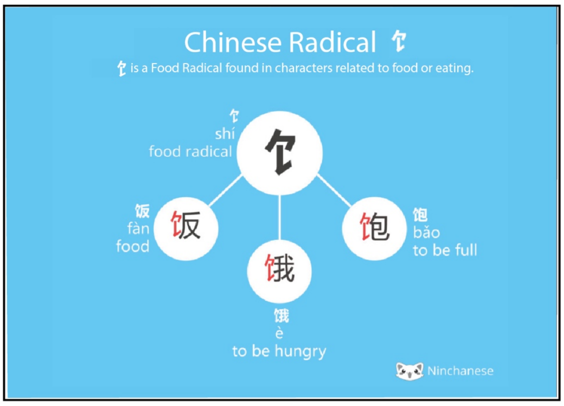
C SR Water
(Peter, 2013)



D SR Heart
(Rowley, 1992)



E SR Hand
(Lohove, 2015)



F SR Food
(Ninchanese Team, 2013)

Note: SR = Semantic Radical

Figure 5-1. Materials in the learn-and-test task in Study 1 (the original materials were given in A4 size and they are scaled down here for the illustration purpose).

The six cases introduced six different SRs (similar level of difficulties) with different VIs: illustrations, diagrams, instructional colour and squares. The six SRs had three to four strokes which correspond to similar level of difficulties. Material A, Material B and Material C introduce SRs with only one type of VIs, e.g., Material A had illustration only. Material D, Material E and Material F presented SRs with combined use of two types of VIs, e.g., Material E had illustrations and diagrams. The six materials showed SRs with three different typefaces: Heiti, Songti and Kaiti.

Materials used in the ranking task: the 31 cases that have VIs for Reading & Memorising were used as visual examples in the ranking task. Participants were asked to rank the ease of the different VIs from the easiest to the hardest. They were asked to do 10 Ranking Questions (RQs) about illustrations, diagrams, squares, instructional colours and typefaces with 10 variables (refers to Table 5-3). For example, participants were asked to rank the ease of the illustrations with modern style and traditional style (refers to RQ4 in Table 5-3). The options of the 10 RQs and the example cases were the same as the visual survey.

Table 5-3. The 10 RQs in the ranking task.

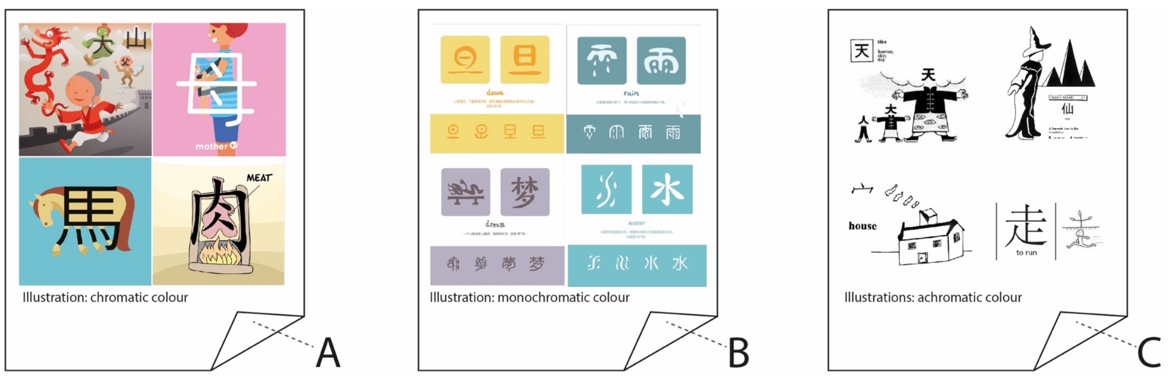
RQs	**Illustrations**	
	Variables	Options (example cases in Appendix II)
RQ 1	Colour	A. Chromatic colour (Case No. 7, 8, 13, 14, 17, 19, 22, 23, 24, 25, 27, 29, 35) B. Monochromatic colour (Case No. 31, 32, 33) C. Achromatic colour (Case No. 1, 2, 3, 5, 6, 7, 9, 10, 28, 30)
RQ 2	Outlines & colours	A. Colour areas only (Case No. 7, 8, 13, 14, 17, 19, 22, 23, 24, 27, 31, 32) B. Outline only (Case No. 3, 6, 9, 10, 28, 30) C. Colour areas with outlines (Case No. 1, 2, 5, 17, 25, 29, 33, 35)
RQ 3	Content styles	A. Modern style (Case No. 1, 2, 3, 5, 6, 7, 8, 9, 10, 14, 19, 22, 23, 24, 25, 27, 28, 29, 30, 31, 32, 33, 35) B. Traditional Chinese style (Case No. 1, 8, 13)
RQ 4	Technique styles	A. Vector-drawing style (Case No. 2, 7, 8, 14, 19, 22, 23, 24, 27, 31, 32) B. Hand-drawing style (Case No. 1, 3, 5, 6, 9, 10, 13, 17, 25, 28, 29, 30, 33, 35)
RQ 5	Combinations	A. Integrated& Imitation (Case No. 6, 7, 8, 22, 23, 24, 25, 27, 28) B. Next & Imitation (Case No. 1, 2, 3, 5, 10, 14, 30, 31,32) C. Next & Description (Case No. 6, 9, 13, 19, 25, 29, 33, 35)
RQ 6	Size contrasts	A. Similar size of illustrations and CCs /SRs (Case No. 6, 7, 9, 10, 22, 23, 24, 27, 28, 29, 30, 31, 32, 33, 35) B. Big illustrations and small CCs /SRs (Case No. 1, 2, 3, 5, 6, 8, 13, 14, 19, 25, 27)
	Diagrams	
RQ 7		A. Structure diagrams with colour coding (Case No. 20) B. Structure diagrams with colour highlights (Case No. 25) C. Cluster diagram with achromatic colour (Case No. 26) D. Cluster diagram with colour highlight (Case No. 14, 16, 19) E. Cluster diagram with colour coding (Case No. 17)

Table 5-3. The 10 RQs in the ranking task. *(continued)*

Squares	
RQ 8	A. Squares with outline only (Case No. 4) B. Squares with black highlights (Case No. 2, 9)
Instructional colours	
RQ 9	A. SRs are colour highlights (Case No. 14, 16) B. SRs are codes with colour (Case No. 12) C. Diagrams are coded with colour (Case No. 17, 20) D. Illustrations are coded with colour (Case No. 25)
Typefaces	
RQ 10	A. Songti (Case No. 6, 7, 10, 11, 12, 18, 30, 33) B. Kaiti (Case No. 3, 4, 5, 9, 13, 17, 19, 20, 23, 25, 26, 28, 35) C. Heiti (Case No. 1, 2, 8, 12, 14, 16, 20, 24, 27)

Note: CC = Chinese Character; RQ = Ranking Question; SR = Semantic Radical

Not all the listed example cases (Appendix II) were shown to the participants, since some options had many example cases while the others had little. Only four visual examples were shown to the participants for each option. If the example cases of one option are less than four, more than one visual example were chosen from one case. Figure 5-2 shows the visual examples of RQ 1 (refers to Table 5-3) and related options (A, B, C) in the ranking task.



Case No.8 (Niemann, 2008)
Case No.22 (Monkimun Team, 2014)
Case No.24 (Hsueh, 2014)
Case No.25 (Lohove, 2015)

Case No.32 (XiaoXiang Hanzi, 2017a).

Case No.1 (Peng, 2012)
Case No.2 (Rowley, 1992)
Case No.6 (Matthews and Matthews, 2007)
Case No.10 (Banno et al., 2009)

Figure 5-2. Visual examples of the RQ 1 and the related options (A, B, C) in the ranking task in Study 1.

5.2.1.3 Procedure

Study 1 had a learn-and-test task and a ranking task. All the participants were asked to do the learn-and-test task first, and then do the ranking task.

Learn-and-test task: all participants were given the six materials (A to F, refers to Figure 5-1) in random order and they were asked to read and learn the SRs within 10 minutes. Then, they were asked to finish a set of memory test, including six Radical Recall Questions (RRQs), six Meaning Recall Questions (MRQs) and six Position Recall Questions (PRQs). They were given the three questions from the RRQs, MRQs to PRQs for the six SRs in three sheets. Each sheet has a type of question (RRQ, MRQ or PRQ) for all the six SRs. For example, the sheet of RRQ has six RRQs for the six SRs. In each question sheet, the participants were not asked to answer the questions from the first SR to the sixth SR.

Ranking task: all participants were given the 10 RQs (Table 5-3) in the ranking task. Each question was shown with two to five sheets (refer to the example in Figure 5-2) and each sheet corresponded to one option of a variable (refer to Table 5-3). The participants were asked to rank the ease of reading and memorising with the sheets. Taking RQ 1 (Table 5-3) as an example (Figure 5-2), the participants were given the three sheets in random order. 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. The researcher wrote down the order, e.g., BAC. This process was repeated for the 10 RQs.

5.2.2 Results

Learn-and-test task: Table 5-4 shows the average per cent accuracy of the learn-and-test task, and the corresponding materials and VIs.

For the average per cent accuracy of the **RRQs**, the results showed that materials that had illustrations had higher accuracy than those that did not have illustrations: Material A (93%) = Material D (93%) > Material B (87%) > Material E (73%) > Material F (53%) > Material C (37%).

For the average per cent accuracy of the **MRQs**, the results also showed that materials that had illustrations had higher accuracy than those that did not have illustrations: Material B (90%) = Material D (90%) > Material A (87%) > Material E (70%) > Material F (63%) > Material C (53%).

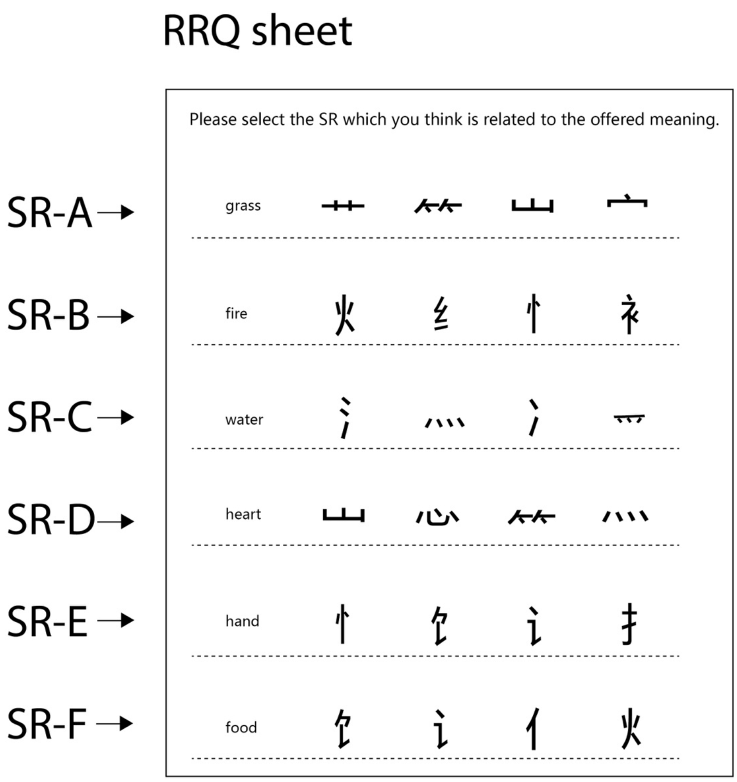
For the average per cent accuracy of the **PRQs**, the results showed that materials that highlighted positions of SRs through colour coding in Material C and squares in Material D had higher accuracy than those materials that did not highlight positions of SRs in Material A, B, E and F: Material C (87%) > Material D (83%) > Material E (67%) > Material A (60%) = Material F (60%).

Table 5-4. The per cent accuracy of the six materials in the learn-and-test task.

Materials	VIs for Reading & Memorising		Accuracy
Material A	**Illustrations** • Chromatic colour • Colour areas only • Vector-drawing style • Integrated & imitation • Similar size of SRs and illustrations	**Typeface** Heiti	RRQs 93% MRQs 87% PRQs 60%
Material B	**Illustrations** • Achromatic colour • Outline only • Hand-drawing style • Integrated & imitation • Similar size of SRs and illustrations	**Typeface** Songti	RRQs 87% MRQs 90% PRQs 53%
Material C	**Instructional colours** • Colour coding • Big CCs and SRs	**Typeface** Heiti	RRQs 37% MRQs 53% PRQs 87%
Material D	**Illustrations** • Achromatic colour • Colour areas only • Vector-drawing style • Next & Imitation • Small SRs and big illustrations	**Squares** Square with black highlights **Typeface** Heiti	RRQs 93% MRQs 90% PRQs 83%
Material E	**Illustrations** • Chromatic colour • Colour areas with outlines • Hand-drawing style • Integrated & imitation • small SRs and big illustrations	**Diagrams** Colour highlighted structure diagrams **Typeface** Kaiti	RRQs 73% MRQs 70% PRQs 67%
Material F	**Instructional colours** • Colour highlight SRs • Small SRs	**Diagrams** Achromatic colour cluster diagrams **Typeface** Heiti	RRQs 53% MRQs 63% PRQs 60%

Note: CC = Chinese Character; SR = Semantic Radical; MRQ = Meaning Recall Question; PRQ = Position Recall Question; RRQ = Radical Recall Question

During the memory test, it was noted that different participants answered the questions of the six SRs in different order. A total of 13 participants answered the questions in the provided order. The left 17 participants answered the questions in different order. Participants had a very similar order to answer the questions in the three testing sheets, i.e., the RRQ sheet, the MRQ sheet and the PRQ sheet. It seems that the order of answering MRQs (the second sheet) and PRQs (the third sheet) were influenced by the RRQs (the first sheet). Therefore, the chosen order for answering the first question (RRQ) should be more trustworthy and would be further analysed. Figure 5-3 shows the RRQ sheet in the learn-and-test task. The 17 participants answered the questions in different order. For example, participant S1P6 answered SR-B firstly and SR-A secondly.



Note: RRQ = Radical Recall Question; SR = Semantic Radical

Figure 5-3. The RRQ sheet in the learn-and-test task in Study 1.

Table 5-5 shows the number of the 17 participants who chose their first (or second, third, fourth, fifth, sixth) question to answer the questions of SR-A (or B, C, D, E, F), and the comparison of the per cent accuracy of the 17 participants and the 30 participants. Thirteen participants chose the SR-A as the first three questions to answer. Fifteen participants chose the SR-B as the first three questions to answer and 12 participants chose the SR-D as the first three questions to answer. The results showed that more participants chose the SR-A, SR-B and SR-D as the first three questions to answer than chose the SR-C, SR-E and SR-F as the first three to answer (refers to Table 5-5). After comparing the per cent accuracy (RRQs) of the 17 participants and the 30 participants, we could draw the conclusion that the accuracy of SR-A (100%), SR-B (93%), SR-D (94%) and SR-E (76%) of the 17 participants were higher than the 30 participants (SR-A: 93%, SR-B: 87%, SR-D: 93%, SR-E: 73%). The accuracy of SR-C (29%) and SR-F (47%) of the 17 participants was lower than the 30 participants (SR-C: 37%, SR-D: 93%, SR-F: 53%).

Table 5-5. The number of the 17 participants who chose their first (or second, third, fourth, fifth, sixth) question to answer the questions of SR-A (or B, C, D, E, F), and the comparison of the per cent accuracy of the 17 participants and the 30 participants.

Materials	SR	1st	2nd	3rd	4th	5th	6th	**RRQ Accuracy**	
								17 participants	30 participants
A	SR-A	8	2	3	4	0	0	100%	93%
B	SR-B	6	4	5	2	0	0	93%	87%
C	SR-C	0	2	1	2	9	3	29%	37%
D	SR-D	2	5	5	4	1	0	94%	93%
E	SR-E	0	3	3	4	3	4	76%	73%
F	SR-F	1	1	0	1	4	10	47%	53%

Note: RRQ = Radical Recall Question; SR = Semantic Radical

The results showed that the earlier the participants chose to answer the question, the higher accuracy they had in the memory test. To be more specific, questions of the SR-A, SR-B, SR-D and SR-E were earlier chosen to answer than questions of SR-C and SR-F by the 17 participants. The accuracy of SR-A (100%), SR-B (93%), SR-D (94%) and SR-E (76%) were higher than SR-C (29%) and SR-F (47%). Therefore, the order that they answered the questions indicated that the earlier to choose SRs, the easier to recall. Considering the VIs in the six materials, Materials A, B, D and E had illustrations, while Materials C and F did not have illustrations. The data of the order and the accuracy showed that learning SRs with illustrations were easier to recall than learning SRs without illustrations when answering the RRQs.

Ranking task: The results of the ranking task showed that the participants had an obvious preference of some variables than the others in terms of ease of Reading & Memorising. Table 5-6 shows the comparison between the results of the ranking task and the visual survey (refers to Section 4.3) for the 10 RQs. If the rates of the top-ranking option and the top proportions in the existing cases are the same option, they are highlighted in red (RQs 1, 2, 3, 6, 7 and 8), If not, they are highlighted in blue (RQs 4, 5, 9 and 10).

For the variables of the illustrations, the top choices of the participants were consistent with the highest existing propositions for the colour (RQ 1), outlines & colours (RQ 2), content styles (RQ 3) and size contrasts (RQ 6) of the illustrations.

Table 5-6. The comparison between the results of the ranking task and the visual survey for the 10 RQs (If the rates of the top-tanking option and the top proportions in the existing cases are the same option, they are highlighted in red. If not, they are highlighted in blue).

RQs	**Illustrations** (26 cases)		Ranking task	Visual survey	
	Variables	Options	Top ranking (rates)	Existing proportions	Cases
RQ 1	Colour	A. Chromatic colour	A. 67%	A. 50%	13 cases
		B. Monochromatic colour	B. 26%	B. 12%	3 cases
		C. Achromatic colour	C. 7%	C. 38%	10 cases
RQ 2	Outlines & colours	A. Colour areas only	A. 60%	A. 46%	12 cases
		B. Outline only	B. 10%	B. 23%	6 cases
		C. Colour areas with outlines	C. 30%	C. 31%	8 cases
RQ 3	Content styles	A. Modern style	A. 87%	A. 88%	23 cases
		B. Traditional Chinese style	B. 13%	B. 12%	3 cases
RQ 4	Technique styles	A. Vector-drawing style	A. 76%	A. 46%	12 cases
		B. Hand-drawing style	B. 23%	B. 54%	14 cases
RQ 5	Combinations	A. Integrated& Imitation	A. 60%	A. 35%	9 cases
		B. Next & Imitation	B. 33%	B. 35%	9 cases
		C. Next & Description	C. 7%	C. 31%	8 cases
RQ 6	Size contrasts	A. Similar size of illustrations and SRs (or CCs)	A. 83%	A. 58%	15 cases
		B. Big illustrations and small SRs (or CCs)	B. 7%	B. 42%	11 cases
	Diagrams (7 cases)				
RQ 7		A. Structure diagrams with colour coding	A. 16%	A. 14%	1 case
		B. Structure diagrams with colour highlights	B. 14%	B. 14%	1 case
		C. Cluster diagram with achromatic colour	C. 8%	C. 14%	1 case
		D. Cluster diagram with colour highlight	D. 33%	D. 43%	3 cases
		E. Cluster diagram with colour coding	E. 29%	E. 14%	1 case
	Squares (3 cases)				
RQ 8		A. Squares with outline only	A. 7%	A. 33%	1 case
		B. Squares with black highlights	B. 83%	B. 67%	2 cases
	Instructional colour (6 cases)				
RQ 9		A. SRs are colour highlights	A.12%	A. 33%	2 cases
		B. SRs are codes with colour	B.67%	B. 17%	1 case
		C. Diagrams are coded with colour	C.13%	C. 33%	2 cases
		D. Illustrations are coded with colour	D.8%	D. 17%	1 case
	Typefaces (31 cases)				
RQ 10		A. Songti	A.0%	A. 26%	8 cases
		B. Kaiti	B.13%	B. 42%	13 cases
		C. Heiti	C.87%	C. 30%	9 cases

Note: CC = Chinese Character; SR = Semantic Radical; RQ = Ranking Question

However, 76% of the participants chose illustrations with vector-drawing styles for the easiest VIs rather than the hand-drawing styles, referring to RQ 4. In the 26 illustration cases, 54% of them used hand-drawing styles. For the combinations (RQ 5) of the illustrations and CCs (or SRs), 60% of the participants chose the Integrated & Imitation combination, while 35% of the 26 illustration cases used it. Another 35% the cases used the Next & Imitation combination. For the variables of the diagrams and the squares, the participants' choices were aligned with the highest existing propositions (refers to Table 5-6), which will not be repeated.

In regard to the instructional colour and typefaces, the highest participants' choices were inconsistent with the highest proportions. Look at RQ 9 about the instructional colour, 67% of the participants chose the option B (refers to Table 5-6) that SRs are coded with colour, while 17% of the six existing cases used the VI that SRs are coded with colour. In the six existing cases, 33% of them used the VIs that SRs were colour highlighted, corresponding to the option A. Another 33% of the existing cases used the VI that diagrams were coded with colour, corresponding to the option C. For the typefaces (RQ 10), 87% of the participants chose Heiti typeface as the easiest typeface for the VIs for Reading & Memorising SRs, while 30% of the 31 existing cases used Heiti typeface. In the existing cases, 42% of them used Kaiti typeface.

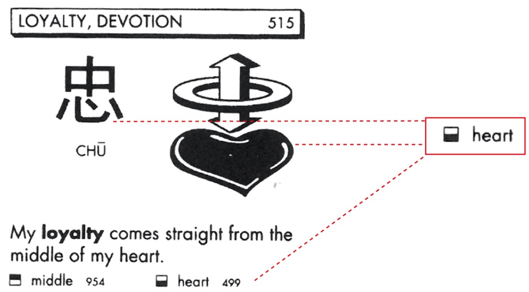
5.2.3 Discussion

The findings of the learn-and-test task align with the cognitive theories (Section 4.2.1). First, learning SRs with illustrations showed higher accuracy than that without illustrations for answering the RRQs and MRQs. Second, the order of answering the RRQs of the 17 participants also showed that learning SRs with illustrations were easier to recall than that without illustrations. It is in line with the dual coding theory and the picture superiority effect that presenting texts with pictures are easier to remember than presenting texts only (Paivio, 1986; Clark and Paivio, 1991; Pettersson, 2014). Moreover, it is consistent with the design suggestions that illustrations enhance memory (Peeck, 1993; Horn, 1998; Male, 2017; Hall, 2011).

The results of the accuracy of the PRQs showed that learning the SRs with the colour coding in Material C and the black highlighted squares in Material D had higher accuracy than the other four materials. In regard to the colour coding, it is consistent with the suggestion that colour increased attention (Winn, 1993; Mijksenaar, 1997; Pettersson, 1998; 2010; 2019) and colour coding enhances memory (Peck and Hannafin, 1988; Bradshaw, 2003; Samara, 2007; Pettersson, 2013c; 2015).

Material F also had colour highlighted on SRs, but the participants did not have a high accuracy to answer the PRQ of SR-F. The reason might be that Material C had colour highlight on big size SRs, while Material F had colour highlight on small size SRs. It is suggested by the focal point principle (Chang et al., 2002; Lipton, 2011; Ali and Peebles, 2013; Pettersson, 2014; Lonsdale and Lonsdale, 2019) that big size elements draw more attention that small size elements.

In terms of the squares, limited literature indicates the function of it. However, understandably, the small squares showed clear information about the structure of CCs and highlighted positions of the SR in CCs. Figure 5-4 shows an example in Material D that the small square shows the information of the SR Heart in the CC Loyalty. However, the squares in the Material D were small and not obvious enough, which did not follow the focal point principle. Therefore, the effectiveness of squares for highlighting positions of SRs needs to be further explored. Material E and F had diagrams, but they did not bring high accuracy for answering the PRQs. Moreover, there were many variables in the six materials, the differences between the three typefaces were not apparent.



Reference: (Rowley, 1992)

Figure 5-4. The small square in Material D shows the information of SR Heart in CC Loyalty.

The results of the learn-and-test task showed that learning with materials with the illustrations, colour coding and squares showed higher accuracy than those without those VIs. However, the materials used in the quasi-experimental study had many variables. The results only showed the potential effectiveness of the illustrations, colour coding and squares. They still need to be further tested in an actual experiment. Moreover, whether the effects of VIs for Reading & Memorising SRs are statistically significant still need to be tested.

In regard to the ranking task, the highest participants' choices were consistent with the highest proportions in the six of the 10 RQs, while the other four RQs were inconsistent.

For illustrations, first, the results showed that the most participants thought illustrations in chromatic colour were easier to read and memorise SRs than achromatic colour and monochromatic colour. The achromatic colour was the least chosen to be easy to read and memorise. It has been stated by Pettersson (2019) that chromatic colours draw more attention than achromatic colours. In the existing cases, 40% of them used illustrations in achromatic colour. Understandably, illustrations in chromatic colours cost more for printing for practical reasons. Therefore, it is suggested to show illustrations in chromatic colour by digital mediums. Chromatic colour illustrations are also suggested in paper-based VIs if the costing is within budget. The effectiveness of monochromatic colour for reading and memorising has not been demonstrated theoretically. Although only 26% of the participants chose the illustrations in monochromatic colour, its effectiveness was also worth to explore.

Second, illustrations with colour areas only (no outlines) were chosen as the easiest to read and memorise by 60% of the participants. In existing cases, 14 cases have illustrations with outlines and 12 cases have illustrations without outlines. The results also showed that illustrations in vector-drawing styles were easier to read and memorise than hand-drawing styles. However, 54% of existing cases used illustrations in hand-drawing styles. The simplicity principle (Dewar, 1999; Wogalter, 1999; Lipton, 2011) suggests that excessive details (Berlyne and Peckham, 1966) and irregular shapes (Berlyne, 1958) are easy to reduce the effect of perception and memory in VIs. The hand-drawing style illustrations were identified by their irregular shapes and edges. Moreover, illustrations both had colour and outlines could be regarded as having too many details. Therefore, the hand-drawing style illustrations and the illustrations with detailed outlines should be avoided for the instructional purpose.

Third, 76% of the participants chose illustrations in the modern styles rather than the traditional Chinese styles. Similarly, 92% of the existing cases had modern style illustrations. It is consistent with the literature suggestion that using global symbols and visual elements for international audiences facilitate understanding and communication (Grove, 1989; McAnany and McAnany, 2009). However, three cases had traditional Chinese style illustrations. Case No. 1 and No. 8 had illustrations that drew traditional Chinese costumes and Chinese dragon. It might be that some authors (or designers) would like to use elements with Chinese style to introduce Chinese culture to international audiences. Case No. 13 had Chinese freehand brushworks[18], which was generally regarded as more

[18] Freehand brush work is a type of Chinese traditional painting, which emphases spiritual characteristics rather than physical similarities of the visible world (Briessen, 2011).

artistic rather than realistic. For the instructional purpose, it is recommended to draw illustrations in a realistic manner rather than a piece of artwork (Brouwer, 1995).

Fourth, the data indicated that the Integrated & Imitation combination of illustrations was more popular than the other two combinations, as 60% of the participants chose the Integrated & Imitation combination as the easiest to learn. However, only 40% of the existing cases had this type of combination. The cognitive load theory (Miller, 1956; Kahneman, 1973; Bower, 1975; Chandler and Sweller, 1991) suggests that separately presenting various sources of information increases memory load. That is to say, the integrated illustrations are theoretically recommended. However, the format of integrating SRs into illustrations are easy to increase the visual complexity, which is against the simplicity principle (Dewar, 1999; Wogalter, 1999; Lipton, 2011), and might increase memory load and influence the effect of learning. Moreover, the effectiveness of the Integrated & Imitation illustrations for learning SRs has not been tested in previous studies. Therefore, the effectiveness of integrated illustrations for learning SRs was further explored in this study (Study 2, Study 3 and Study 5).

Fifth, 83% of the participants chose the similar size of illustrations and SRs rather than the big size illustrations and small size SRs. The focal point principle suggests that big size elements draw more attention than small size elements (Chang et al., 2002; Lipton, 2011; Ali and Peebles, 2013; Pettersson, 2014; Lonsdale and Lonsdale, 2019). However, 46% of the existing cases had big size illustrations and small size SRs (or CCs). The instructional illustrations should assist in learning SRs, rather than draw attention of leaners. The focal point of VIs should be not an illustration. Therefore, the design development should avoid that illustrations draw more attention to learners than SRs.

In regard to diagrams, the participants considered that cluster diagrams were easier to read and memorise than structure diagrams. Look at the existing cases, diagrams were more often used to introduce a group of CCs rather than a single CC or SR. This study aimed to develop VIs for enhancing learning individual SRs rather than presenting a collection of SRs. Therefore, diagrams were not considered in developing prototypes.

For square shapes, 83% of the participants considered that the black-highlighted squares were easier to read and memorise than outline squares. As it has been discussed in the visual survey, that squares with chromatic colour might be more effective than the black squares (Pan, 2010). Hence, chromatic colour squares need to be further explored.

In terms of instructional colour, 67% of the participants regarded that SRs coded with colour were easy to read and memorise. This is in line with the literature review that colour coding is suggested as a useful tool for enhancing memory (Peck and Hannafin, 1988; Bradshaw, 2003; Samara, 2007; Pettersson, 2013c; 2015). However, only one case had this type of colour coding. The effectiveness of colour coding for learning SRs needs to be explored. The results also showed that colour-coded illustrations were the least chosen type for the easiest VIs for Reading & Memorising, and it only existed in one case (Case No. 25, Lohove, 2015). In the case No. 25, the colour-coded illustrations showed the information of tones of CCs. The colour-coded illustrations in case No. 25 were combined presented with illustrations that had decorative colour, which reduced the information of colour coding and was easy to confuse readers. The above two reasons may explain why the participants thought the colour-coded illustrations was ineffective for Reading & Memorising SRs. The effectiveness of colour-coded illustrations was further explored in this study.

In regard to the typefaces in the VIs for Reading & Memorising, Heiti typeface was chosen as the easiest typeface for the learning purpose by 87% of the participants rather than Songti and Kaiti typefaces. Heiti typeface is a typical Chinese sans serif typeface (Zhang, 2011). As sans serif typefaces are proposed to use in headings, they are generally looked clear and easy to recognise (Simmonds and Reynolds, 1994; Schriver, 1997; Pettersson, 2013a). Moreover, serif typefaces (Songti and Kaiti) have extra decorative terminals of some strokes (Sevilla, 2002; Samara, 2007; Stock-Allen, 2011; Tselentis et al., 2012), which increase the visual complexity, especially when they were integrated with illustrations. Hence, Heiti typeface was used to develop new design in the following studies.

5.2.4 Summary

Study 1 preliminarily explored the effectiveness of different VIs in existing cases for Reading & Memorising SRs. Illustrations, colour coding and instructional squares showed potential effects for enhancing learning SRs in the learn-and-test task. However, the effects of the VIs in the learn-and-test task were influenced by many variables, such as, different layouts, sizes of SRs, colours and so on. Hence, the results of the learn-and-test task provided a broad idea for further explorations.

The ranking task investigated the participants' opinions about different variables in illustrations, diagrams, squares, instructional colour and typefaces in terms of the ease of reading and memorising SRs. The results of the ranking task were compared with the results of the visual survey. They were discussed with the theoretical suggestions in the literature review. Six of the 10 design variables (10 RQs) were chosen as the easiest to read and memorise by the most participants, and these variables accounted for the majority of existing cases, e.g., illustrations in modern styles (refers to Table 5-5). Four of the 10 design variables were chosen as the easiest by the most participants, but these variables accounted for small proportions, e.g., SRs were coded with colour (refers to Table 5-5). The results of the ranking task narrowed down the broad range of design variables and prepared for the design development in Study 2.

5.3 Study 2: iterative usability tests on prototypes for Reading & Memorising SRs

Based on the results of Study 1 and the theoretical suggestions of literature review (Section 4.2), Study 2 aimed to produce, refine and test the design prototypes. Moran (2019) stated that an iterative usability test is a vital and appropriate approach for discovering design issues and improving the design. Study 2 contained two iterative usability tests: Usability Test 1 and Usability Test 2. The two iterative usability tests produced prototypes for enhancing reading and memorising SRs by non-specialist beginners. Moreover, Study 2 made it well-prepared for Study 3, which was an experimental study on the prototypes.

5.3.1 Usability Test 1

5.3.1.1 Methods

Materials: samples A1, A2, A3, A4 and A5 (Appendix III) were developed, and each sample had minor differences in detail. Figure 5-5 shows the five samples of the initial prototypes (SR Fire was taken as an example). All the five samples had the same layout, size and typeface. Each page had three parts: an SR (part 1), a related CC (part 2) and four small size related CCs (part 3). Each SR and CC had English translations. In the five samples, a small square in the middle part highlighted the position of SR in CCs. The squares in A1 and A3 were black highlighted, while the squares in A2, A4 and A5 were colour coded. The details of all the five samples will be explained as follows.

A1: simple form VI. The whole page displayed an SR and related CCs clearly with no illustrations or instructional colours.

A2: colour coding VI. The colour coding was designed to highlight the positions of SRs in CCs. In A2, SRs and the squares had the same colour. The colour coding had four colours (Figure 5-5), which were coded with four positions of SRs in CCs: green (left), orange (right), blue (top, top and left) and brown (bottom, bottom and left). The colours were chosen according to the commonly appeared colours in nature. Blue was chosen as the top-colour, since the sky is blue, while the bottom-colour was brown because the ground is brown. The left-colour green was related to trees, and the right-colour orange was related to fruits. These were designed for remembering the positions easier rather than a connection with meanings.

A3: integrated illustration VI. The whole page displayed an SR and related CCs with integrated illustrations in chromatic colour. The square was black rather than colour coded.

A4: integrated illustration and colour coding VI. The integrated illustration in A4 was the same as A3. The square in A4 was the same as A2.

A5: colour-coded integrated illustration VI. The integrated illustration had the same colour as the colour coding in A2 and A4.

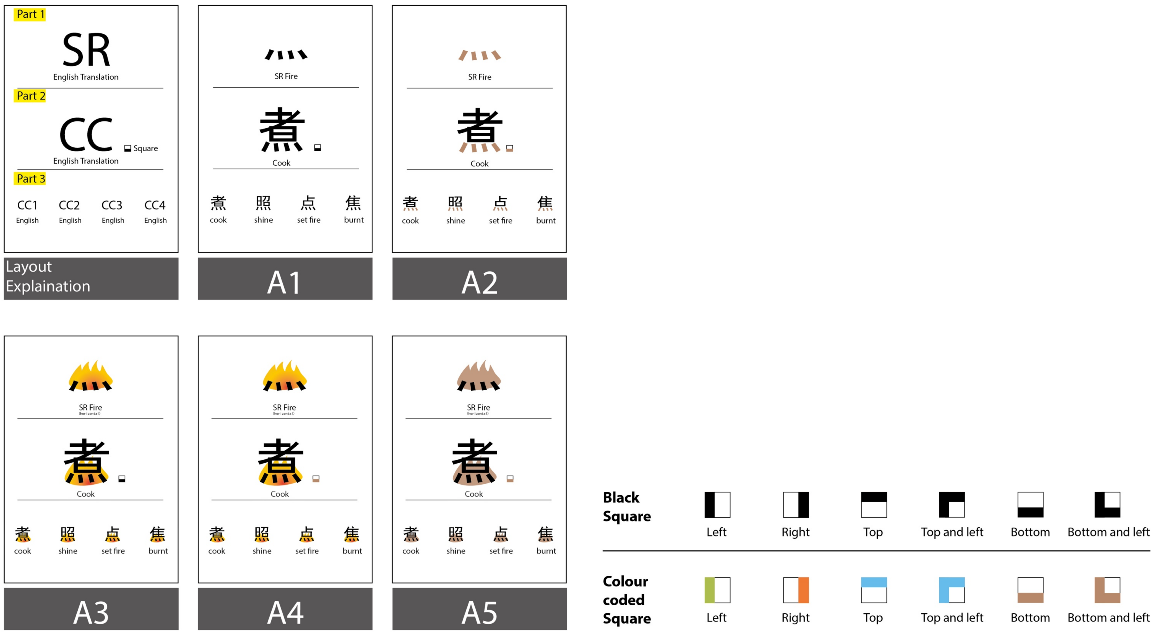
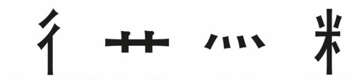
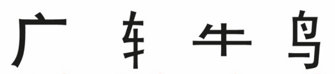


Figure 5-5. An example of samples A1, A2, A3, A4 and A5 and the visual explanations of the black squares and the colour coded squares.

Twenty SRs were designed with the five samples (four SRs per sample). All the 20-page VIs were listed in Appendix III. Table 5-7 shows the 20 SRs in groups (five groups in total). Each group of SRs had similar difficulties because they had the same stroke numbers. Each VI sample was applied with a group of SRs and each group of SRs had 16 strokes in total. The stroke numbers of the SRs were highlighted in red in Table 5-7.

Table 5-7. The 20 SRs used in samples A1, A2, A3, A4 and A5 in Usability Test 1.

A1	**SR Group 1**	 Soil (3) Wood (4) Whip (4) Clothes (5)
A2	**SR Group 2**	 Water (3) Shell (4) Sun (4) Eye (5)
A3	**SR Group 3**	 Slow-walk (3) Grass(3) Fire (4) Eye (6)
A4	**SR Group 4**	 Walk(3) Fire (4) Heart (4) Crop (5)
A5	**SR Group 5**	 Shelter (3) Vehicle (4) Ox (4) Bird (5)

Note: SR = Semantic Radical
The stroke numbers of SRs are highlighted in red in brackets.

Participants: five participants were recruited. They were ab initio beginners of CCs and SRs in the 19-48 age range (mean age 28). Three were female and two were male. They were from three different nationalities: one Nigerian, one Brazilian and three British. They all lived or studied in the UK. The five participants were named S2U1P1, S2U1P2, S2U1P3, S2U1P4 and S2U1P5.

Procedure: first, the participants were informed about the process of tasks and information of the colour coding. Then, they were asked to learn the 20 SRs with the five samples from A1 to A5 without time limit. They were asked to do a memory test after learning each sample, and this procedure was repeated five times (five samples). The memory test was setting as a paper-administered test. The five tests included 20 RRQs, 20 MRQs and 20 PRQs. All questions were MCQs. Last, all the five participants were asked opinions about the learning experience and suggestions about the five samples.

5.3.1.2 Results and discussion in Usability Test 1

The results of Usability Test 1 included two parts: the average per cent accuracy, the time of learning, and the speed of answering (part one); and participants' spontaneous speaking during the learning task and the suggestions after the memory test (part two).

Part one: Table 5-8 shows the results of the average per cent accuracy, learning time and answering speed. The average answering speed was the average time spent for answering the 60 questions of each participant. The average per cent accuracy of the RRQs showed that learning with samples A1 (45%) and A2 (40%) had lower accuracy than A3 (70%), A4 (70%) and A5 (85%). Similarly, the average per cent accuracy of the MRQs showed that learning with samples A1 (50%) and A2(45%) had lower accuracy than A3 (65%), A4 (75%) and A5 (85%).

However, the results of the PRQs showed a different trend. The accuracy of the PRQs showed that learning with sample A1 (45%) had lower accuracy than A2 (75%), A3 (75%), A4 (60%) and A5 (80%). The average learning time from A1 to A3 showed a decrease from 110s to 59s. Then, the average learning time showed a slightly increase from A3 (59s) to A4 (67s). Next, learning with A5 (63s) showed four seconds less. The answering speed showed a decrease from A1 (87s) to A5 (64s).

Table 5-8. The average per cent accuracy, learning time and answering speed of samples A1, A2, A3, A4 and A5 in Usability Test 1.

Sample: VIs	**Per cent accuracy**			**Learning time** (s)	**Answering Speed** (s)
	RRQs	MRQs	PRQs		
A1: simple	45%	50%	45%	110	87
A2: colour coding	40%	45%	75%	85	84
A3: integrated illustration	70%	65%	75%	59	68
A4: integrated illustration and colour coding	70%	75%	60%	67	67
A5: colour-coded integrated illustration	85%	85%	80%	63	64

Note: MRQ = Meaning Recall Question; PRQ = Position Recall Question; RRQ = Radical Recall Question; VI = Visual Instruction

Part two: the participants pointed out some design issues and provided several suggestions. The essential viewpoints will be clarified as follows.

For the testing experience and the design samples, the participants had three opinions. First, the participants stated that all the five samples lacked a clear visual focus of SRs. They indicated that the middle part of the page drew more attention than other parts. The middle part was a big size CC, which was not the most important information for the learning purpose of this study. Second, the participants stated that they were not familiar with SRs and different SRs were very similar to them. This statement provided evidence for the necessity of VIs for enhancing learning SRs by non-specialist beginners. It also proved the feasibility of using different SRs with similar difficulties in the test, as different SRs were similar objects to the participants. Last, the participants pointed out that the squares for highlighting positions of SRs were too small. They indicated that the small squares were easy to be ignored, but they held positive opinions about the effect of squares. Therefore, for all the five samples, the visual focus of each page and the size of squares needed to be adjusted.

In each sample, the participants showed different points of views. Sample A1 was agreed by all the participants as the hardest to memorise, which was used as a control sample in the following studies.

In terms of the colour coding in sample A2, participants S2U1P1, S2U1P2, S2U1P4 and S2U1P5 held positive opinions about it, as they stated that the colour made it easier to learn and memorise SRs. Moreover, they pointed out that colour highlighted the SRs in the CCs, separated the CCs into parts and showed connections between the SRs and the CCs. Participant S2U1P2 described the learning experience with colour coding as 'magnetism', which well explained the connection function of the colour coding. Participant S2U1P3 held a neutral opinion about the colour coding. He explained that when he saw the colour, he thought it would be easier to learn, and then he spent little time on it. After the learning task, he found that he could not remember it, but he did not know it was caused by the colour coding or the short learning time. In order to avoid this situation in the following studies, the learning time needs to be controlled strictly.

As for the integrated illustrations in samples A3, A4 and A5, all the participants held positive opinions about the effect of enhancing learning. They indicated that the integrated illustration not only informed the knowledge of SRs but also made it easy to recall. Moreover, they stated that learning with the integrated illustrations was interesting and enjoyable.

In terms of the colour of the integrated illustrations, the participants showed different opinions. Participants S2U1P4 and S2U1P5 stated that learning with sample A4 was easy. They explained that working with different colours for illustrations and colour coding was not difficult for them, and they could remember them separately. Participants S2U1P4 and S2U1P5 said that colour-coded illustrations in sample A5 were strange and unnecessary. On the contrary, participants S2U1P1 and

S2U1P2 stated that learning with sample A4 was confusing and difficult to remember. They preferred the simplified and consistent colour in sample A5. Participant S2U1P3 stated that samples A3, A4 and A5 did not have too many differences for him.

Among the five participants, participants S2U1P3 and S2U1P5 pointed out that the SR Rice illustration (a-bowl-and-chopsticks-of-rice) needed to be adjusted, as they were not familiar with chopsticks. Thus, the illustration would not assist in memorising the SR Rice.

The results of the per cent accuracy showed that learning with the integrated illustrations (A3, A4 and A5) had higher accuracy in answering the questions (RRQs, MRQs and PRQs) than learning without the integrated illustrations (A1 and A2). Moreover, four of the five participants held positive opinions about learning with the integrated illustrations. To be more specific, learning with the integrated illustrations not only assisted with memorising SRs but also making the learning experience interesting and enjoyable. The results of Study 1 only showed that learning with the illustrations facilitated memorising the shapes and meanings of the SRs. However, the results showed that the illustrations also assisted in memorising the positions of SRs. Thus, the effect of the integrated illustrations still needs further tested in full scale experimental study.

Learning with the colour coding in A2 and the integrated illustrations in A3, A4 and A5 had higher accuracy in answering the PRQs than the simple VI in A1. Among these samples, sample A4 (60%) had slightly lower accuracy of the PRQ than the other three samples (A2: 75%; A3: 75%; A5: 80%). The low accuracy of A4 might be because that A4 used the illustrations with decorative colour and the squares with colour coding together, which might bring negative influences on memorising. The effect of the colour coding VI in A2 was consistent with the result of Study 1. However, the two different combinations of the colour coding and the integrated illustrations in A4 and A5 need further exploration.

The results of the learning time showed a decreasing trend, while the answering speed showed an increasing trend from A1 to A5. It might be because that the participants needed a shorter learning time with the later given samples than the earlier ones. Similarly, the participants used a slower speed for answering the questions with earlier tests than the later ones. The order of learning with the five samples might influence the results of the answering speed. Moreover, the order might also influence the results of the accuracy, which was called the carry-over effect. To minimise the carry-over effect, the order of learning and testing with different samples needed to be randomised. Putting the five samples together and randomising them in the learn-and-test task might be a solution. However, it was unsure whether learning 20 SRs without a break is too difficult for ab initio beginners or not.

Next, the design issues and suggestions will be discussed. First, the participants indicated that all samples lacked a precise visual focus of SRs. The reason might be that the layout of the VIs was an average of three parts. The VIs for the SRs and the CCs did not have obvious differences, e.g., colour and size. The layout and other visual elements should be adjusted to make the visual focus of SRs clearer. Second, the squares for highlighting positions of the SRs were easily ignored, as they were too small. Therefore, the above two design issues needed to be adjusted to make them more suitable for the learning purpose and increasing the learning outputs. These two suggestions were also in line with the focal point principle that big size visual elements drew attention (Chang et al., 2002; Lipton, 2011; Ali and Peebles, 2013; Pettersson, 2014; Lonsdale and Lonsdale, 2019). Last, the participants pointed out that they were unfamiliar with the chopstick illustration of the SR Rice, as it was connected to Asian culture. As the results shown in Study 1, illustrations with traditional Chinese styles and elements were not effective for enhancing learning SRs. Although chopsticks were not a traditional element, they were far away from western culture. It was suggested that using global visual elements was more straightforward for communication for international audiences (Grove, 1989; McAnany and McAnany, 2009). Thus, the illustration for the SR Rice should be changed.

5.3.2 Usability Test 2

5.3.2.1 Methods

Materials: based on the results of Usability Test 1, the five samples of VIs for Reading & Memorising SRs were adjusted: B1, B2, B3, B4 and B5 (Appendix IV). Usability Test 2 used the same 20 SRs as the Usability Test 1 did. In order to make the test more rigorous, the learning time was set the same for all participants. For setting the identical length of learning time, the materials were displayed on an 11-inch tablet, with 230mm×160mm size of each page. The design adjustment from Usability Test 1 to Usability Test 2 will be introduced next.

Table 5-9 shows the design issues found in Usability Test 1 and how they were addressed in Usability Test 2. First, to address the design issue of visual focus, the layout was adjusted. At the same time, some visual elements were reduced in terms of visual perception. Figure 5-6 shows an example of design adjustment from Usability Test 1 (A3) to Usability Test 2 (B3). For the layout, A3 has three average parts (1:1:1) while B3 has two parts (7:10). The most significant information for every page should be the target learning SR. All the other information should assist in understanding and memorising the targeted SR rather than distract participants’ attention. Therefore, the proportion of a page in A3 for the SR and the related CCs was 5:10, and the proportion in B3 was adjusted to 7:10. Moreover, the portrait layout in A3 was adjusted to a landscape layout in B3 for adapting the new proportion and the layout. To reduce some elements of visual perception, the repeated illustrations with CCs in A3 were reduced to only one illustration with the SR in B3. The white background in A3 was adjusted to grey in the part of showing CCs (the right part of the page) in B3 to reduce the colour contrast. The above two adjustments were based on the focal point principle and the contrast principle, which indicated a bigger size, or a stronger colour draw more attention instead of a smaller size or a weaker colour (Chang et al., 2002; Lipton, 2011; Ali and Peebles, 2013; Pettersson, 2014; Lonsdale and Lonsdale, 2019). The four small, related CCs in A3 were reduced to three in B3. All the above adjustment enriched the visual focus of the VIs.

Table 5-9. The design issues found in Usability Test 1 and how they were addressed in Usability Test 2.

Design issues	**Design adjustment**		
		Materials in Usability Test 1	**Materials in Usability Test 2**
1. The visual focus was not clear.	**Adjust layout**	5:10 Portrait	7:10 Landscape
	Reduce	Repeated illustrations White background Four small CCs.	Only one illustration Grey background Three small CCs.
2. The square was easy to be ignored.	**Adjust size**	0.7 cm × 0.7 cm	1.5 cm × 1.5 cm
	Repeat	One square	Two squares
	Add element	No dashed line box next to SR	Add a dashed line box next to SR
3. The illustration for SR Rice was not informative enough.	**Change elements**	A bowl of rice with chopsticks	A bag of rice

Note: CC = Chinese Character; SR = Semantic Radical

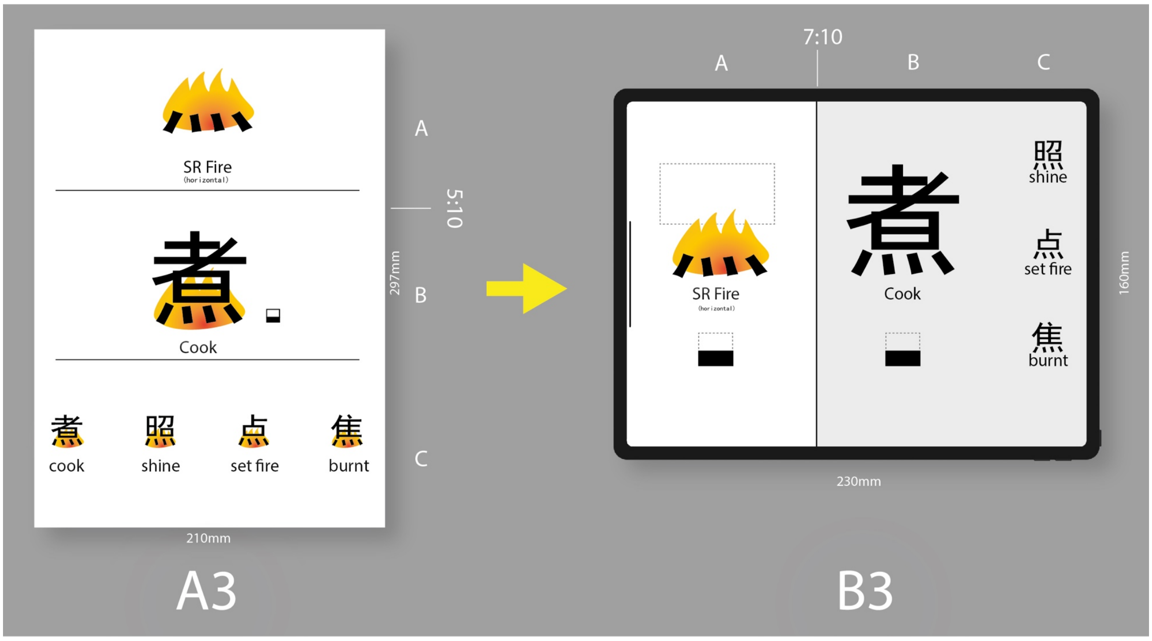


Figure 5-6. The design adjustment from sample A3 to sample B3.

Second, to address the design issue of the squares, three places were adjusted. Initially, the size of the squares was expanded from 0.7 cm^2 to 1.5 cm^2. Apart from adjusting the size of the squares, the square next to the CC in A3 was also presented next to the SR in B3. Moreover, a dashed line box was added next to the SR in B3 to show the position of the SR in the CC, which corresponded to the dashed line in the square. All the adjustment applied to B1, B2, B3, B4 and B5. Last, to address the issue of the SR Rice illustration, the illustration of a-bowl-and-chopsticks-of-rice in Usability Test 1 was replaced by the illustration of a-bag-of-rice in Usability Test 2 (Figure 5-7).

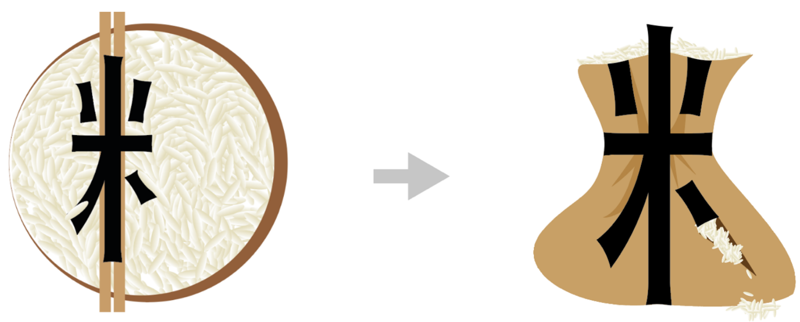


Figure 5-7. The illustration of a-bowl-and-chopsticks-of-rice in Usability Test 1 was replaced by the illustration of a-bag-of-rice in Usability Test 2.

Participants: five participants were recruited. They were all ab initio beginners of CCs and SRs in 20-32 age range (mean age 25). Three were male, and two were female. They lived or studied in the UK and came from three different nationalities: one Maltese, one Indian and three British. They were named as S2U2P1, S2U2P2, S2U2P3, S2U2P4 and S2U2P5.

Procedure: participants were informed the process of the tasks and the information of the colour coding before the learning task. Then, they were asked to learn the 20 SRs with the five samples (B1, B2, B3, B4 and B5) in random order without a break. All the 20-page samples (Appendix IV) were presented with an 11-inch tablet. Each page remained 20 seconds, and then it automatically went to the next page. The 20-second time for each page was achieved by using Microsoft PowerPoint.

After the learning task, they were asked to finish an online memory test, including 60 MCQs (20 RRQs/20 MRQs/ 20 PRQs). To minimise the carry-over effect, the 60 MCQs were shown to participants in random order and the order of options of each MCQ was shuffled for each participant. This was achieved by the Google Forms survey tool. All the participants had to answer the questions with the given order, and they were not allowed to go back to change any answers they had chosen. The whole process of the testing was screen-recorded to record the answering speed. After testing, all the participants were asked their opinions about the design and the testing process.

5.3.2.2 Results and discussion in Usability Test 2

Usability Test 2 aimed to address the design issues found from Usability Test 1 and get ready for the full-scale experiment (Study 3). The results of the Usability Test 2 included two parts: the average per cent accuracy, answering speed (part one) and the participants' opinions about the design and the process of the test (part two).

Part one: Table 5-10 lists the average percent accuracy of the five samples, including RRQs, MRQs and PRQs. The accuracy of the RRQs demonstrated that learning with B1 (55%) and B2 (50%) had lower accuracy than that with B3 (65%), B4 (70%) and B5 (80%). Similarly, the accuracy of the MRQs showed that learning with B1 (50%) and B2(55%) had lower accuracy than that with B3 (70%), B4 (70%) and B5 (80%).

However, the accuracy of PRQs showed a different trend. The accuracy of PRQs showed that learning with B1 (50%) had lower accuracy than that with B3 (65%) and B4 (60%). B2 (75%) and B5 (75%) had the same highest accuracy.

Table 5-10. The average per cent accuracy and the answering speed of samples B1, B2, B3, B4 and B5 in Usability Test 2.

Sample	**Per cent accuracy**			**Answering speed** (s)			
	RRQs	MRQs	PRQs	RRQs	MRQs	PRQs	Sum
B1: simple	55%	50%	50%	23	29	29	81
B2: colour coding	50%	55%	75%	24	25	22	71
B3: integrated illustration	65%	70%	65%	18	15	20	53
B4: integrated illustration and colour coding	70%	75%	60%	19	15	20	54
B5: colour-coded integrated illustration	80%	80%	75%	20	19	15	54

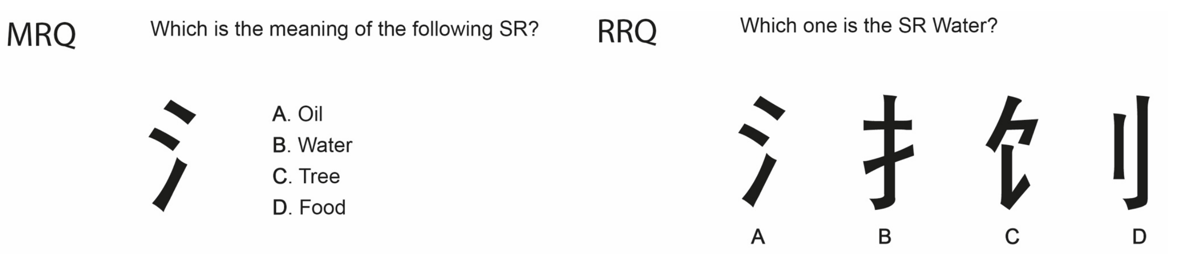
Note: MRQ = Meaning Recall Question; PRQ = Position Recall Question; RRQ = Radical Recall Question

Table 5-10 also shows the answering speed of the 20 RRQs, 20 MRQs, 20 PRQs and sum of the 60 questions together. The sum results showed that participants answered questions B3 (53s), B4 (54s) and B5 (54s) with faster speeds than that of B1(81s) and B2 (71s). Looking at the individual speed of answering the 20 RRQs, 20 MRQs, 20 PRQs, the results showed that participants answered questions B1 and B2 with slower speeds than that of B3, B4 and B5 of all the three questions (details in Table 5-10), which showed a similar trend with the sum time.

Comparing the VIs in different samples, the results displayed that the participants had higher average per cent accuracy and faster speeds for answering RRQs and MRQs when learning with the integrated illustrations in B3, B4 and B5. The results of the PRQs showed that the participants had higher accuracy when learning with the colour coding in B2 (75%) and the colour-coded integrated illustration in B5 (75%) than the other three samples (B1:50%, B3:65% and B4:60%). The participants answered the PRQs of B5 (15s) with a faster speed, compared with the other four samples (B1:29s, B2:22s, B3:20s and B4:20s). That is to say, the participants recalled the positions of SRs with faster speeds if they learnt them with the colour-coded integrated illustrations in B5. Since the small-scale study, this research could only conclude a rough trend from the results of the accuracy and the answering speed.

Part two: the participants were satisfied with the samples. The feasibility of the overall process of the study was confirmed, including the screen-based learning task and the online memory test. First, the 20-second learning time of each SR was feasible and appropriate for ab initio beginners, which was concluded from the participants' calm and contained learning behaviours. The 20-second learning time was reconfirmed by asking them after the test. Second, it was achievable to ask ab initio beginners to learn the 20 SRs continuously and answer the 60 questions after learning them immediately. Depending on different participants, the whole process lasted 30 to 40 minutes for each participant, which was acceptable by asking the participants.

The participants also demonstrated an **issue** that a RRQ and an MRQ of an identical SR should not be asked at short-time intervals, which might show possible answers to each other. For example, Figure 5-8 shows the MRQ and RRQ of SR Water. The options of the MRQ and RRQ might show the possible answers to the participants, as this happened in the Usability Test 2 and needed to be avoided in the following study. Therefore, a RRQ and an MRQ of an identical SR needed to be separated by a certain number of questions of other SRs. After testing, participant S2U2P1 stated that he might forget most of the SRs after a few days and doubt the effectiveness of the colour coding and the illustrations for long-term memory, which meant that the long-term memory needed to be tested in a full-scale experiment.



Note: MRQ= Meaning Recall Question; RRQ = Radical Recall Question; SR = Semantic Radical

Figure 5-8. The MRQ and RRQ of SR Water.

5.3.3 Summary

In summary, Study 2 (Usability Test 1 and Usability Test 2) produced a set of considered and ready-to-test VIs from a relatively less developed concept and prototype. The study method was also transformed from a paper-based test to a screen-based test for a more rigorous study. The two iterations usability tests not only developed the design prototypes but also allowed the researcher to know more about ab initio beginners, including how they interacted with the VIs and how they learnt the knowledge of the SRs.

The results of Study 2 showed that the participants had higher per cent accuracy and faster speeds for answering the RRQs and MRQs in the memory test when learning SRs with the illustrations than that without the illustrations. The participants had higher accuracy of answering the PRQs in the memory test when learning SRs with the colour coding and the colour-coded illustrations than the other VIs. The participants also answered the PRQs with a faster speed when learning SRs with the colour-coded illustrations than the other VIs. The significance of the above effect would be further tested in the full-scale study (Study 3). All the results of Study 1 and Study 2 built a firm foundation for Study 3.

5.4 Study 3: an experimental study on VIs for Reading & Memorising SRs

According to the results of Study 1 and Study 2, the effect of the integrated illustrations and colour coding for enhancing learning SRs needed to be examined. Study 2 preliminarily investigated the effect of the integrated illustrations and the colour coding for learning SRs.

Study 3 aimed to examine the effect of the integrated illustrations and the colour coding for learning SRs in an immediate and one-week-delay memory tests. The null hypothesis (H_0) was that the integrated illustrations and the colour coding had no effect on memorising Chinese SRs.

5.4.1 Methods

5.4.1.1 Participants

A total of 30 participants were recruited. The age range of the participants was from 19 to 31 with a mean age of 22. They were ab initio beginners of CCs and SRs, 16 were female and 14 were male. All the participants have lived or studied in the UK. They came from 12 different nationalities: 19 British, two Polish, two Saudi Arabians, one Spanish, one Brazilian, one Egyptian, one Mexican, one Sri Lankan, one Ugandan and one Iranian. They were named from S3P1 to S3P30.

5.4.1.2 Materials

The VIs and the 20 SRs used in Study 3 were identical to the VIs and the SRs in Usability Test 2 in Study 2 (Appendix IV). Apart from the VIs, the participants were shown two different versions of introductions (A and B, refers to Figure 5-9). Introduction A and B had the same textual content but different colours for squares (A: black; B: colour coding). The textual content introduced the basic knowledge of CCs and SRs that participants needed to know before the learning task. The introductions were paraphrased from the Chinese language textbook (Lu, 2016) to foreign language students, which were used in the University of Leeds.

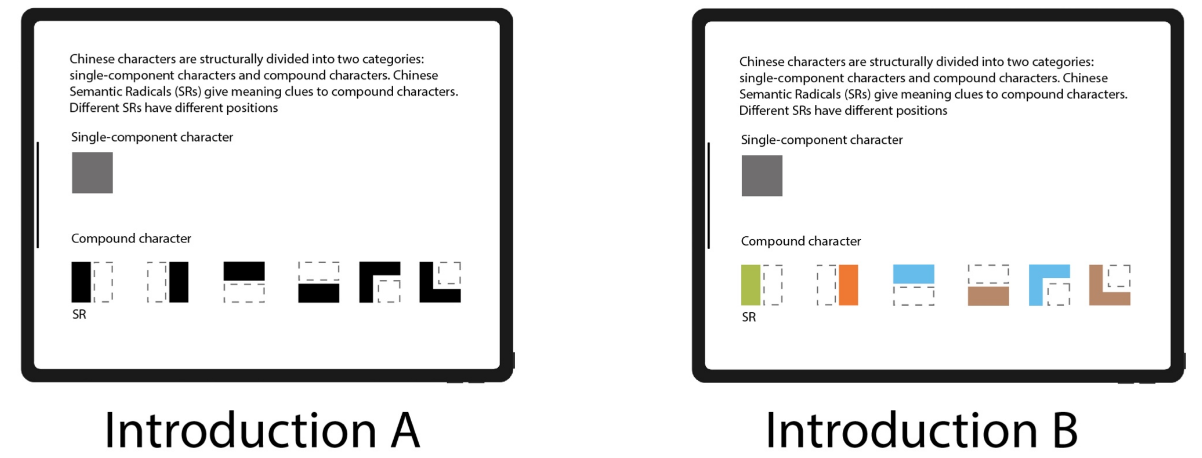


Figure 5-9. Materials of introductions A and B used in Study 3.

5.4.1.3 Procedure

First, all the participants were asked to read the introductions A and B. The researcher did not give any extra verbal explanations about the definition of Chinese SRs to any participants. They were informed that some pages presented with black and white squares (i.e., B1 and B3) and the others presented with colour coding squares (i.e., B2, B4 and B5). Therefore, they were shown the two different versions of introductions (A and B, refers to Figure 5-9).

Then, they were asked to read and try to memorise the 20 SRs when reading the 20-page VIs, which were displayed in random order on an 11-inch tablet. They were presented with Microsoft PowerPoint, with one page per slide. Each slide was set to present 20 seconds and then go to the next one. All the participants used the same tablet.

After the learning task, they were asked to have an online memory test (i.e., IT). In order to record the answering speed, the test processes were screen-recorded. A repeated online memory test (i.e., 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 of the memory test and were asked to finish it within that specific date, which was seven days after their IT.

The memory test contained 60 questions, including 20 MRQs, 20 PRQs and 20 RRQs. Table 5-11 listed the 60 questions about samples B1, B2, B3, B4 and B5 in Study 3. For example, in the column of B1 (Table 5-11), SR1-M is the MRQ of SR1, SR1-P is the PRQ, and SR1-R is the RRQ. As found in the Usability Test 2, a RRQ and an MRQ of an identical SR should not be asked one after another or at short-time intervals, which might show possible answers to each other. To avoid this situation, a RRQ and an MRQ of a specific SR needed to be separated by some questions of other SRs. Therefore, as is shown in Table 5-11, the 60 questions of the five samples were highlighted with three colours, which represented three groups. In the memory test, the three groups of questions were asked in random order, while the order of the 20 questions in each group was constant. Table 5-12 showed the order of the 60 questions in the three groups. Therefore, the participants had to answer at least 19 other questions between a RRQ and an MRQ of an identical SR. This strategy could minimise the carry-over effect.

An online survey about the testing materials was conducted after the DT. The participants were asked to choose one of the samples as the most effective instruction for them to learn. Then, they were asked to measure the given functions of the integrated illustrations, and the colour coding with a five-point Likert scale.

Table 5-11. Sixty questions asked about the samples B1, B2, B3, B4 and B5 in Study 3.

B1	B2	B3	B4	B5
SR1-M	SR5-M	SR9-M	SR13-M	SR17-M
SR1-P	SR5-P	SR9-P	SR13-P	SR17-P
SR1-R	SR5-R	SR9-R	SR13-R	SR17-R
SR2-M	SR6-M	SR10-M	SR14-M	SR18-M
SR2-P	SR6-P	SR10-P	SR14-P	SR18-P
SR2-R	SR6-R	SR10-R	SR14-R	SR18-R
SR3-M	SR7-M	SR11-M	SR15-M	SR19-M
SR3-P	SR7-P	SR11-P	SR15-P	SR19-P
SR3-R	SR7-R	SR11-R	SR15-R	SR19-R
SR4-M	SR8-M	SR12-M	SR16-M	SR20-M
SR4-P	SR8-P	SR12-P	SR16-P	SR20-P
SR4-R	SR8-R	SR12-R	SR16-R	SR20-R

Note: SR = Semantic Radical; M = Meaning; P = Position; R = Radical

Table 5-12. The asking order of the 60 questions in the three groups.

Group 1	SR1-M	SR5-P	SR9-R	SR13-P	SR17-M	SR2-P	SR6-R	SR10-P	SR14-M	SR18-P
	SR3-R	SR7-P	SR11-M	SR15-P	SR19-R	SR4-P	SR8-M	SR12-P	SR16-R	SR20-P
Group 2	SR1-R	SR5-R	SR9-M	SR13-M	SR17-R	SR2-R	SR6-M	SR10-M	SR14-R	SR18-R
	SR3-M	SR7-M	SR11-R	SR15-R	SR19-M	SR4-M	SR8-R	SR12-R	SR16-M	SR20-M
Group 3	SR1-P	SR5-M	SR9-P	SR13-R	SR17-P	SR2-M	SR6-P	SR10-R	SR14-P	SR18-M
	SR3-P	SR7-R	SR11-P	SR15-M	SR19-P	SR4-R	SR8-P	SR12-M	SR16-P	SR20-R

Note: SR = Semantic Radical; M = Meaning; P = Position; R = Radical

5.4.2 Results

The results of Study 3 include three parts. The first part is the results of the memory test, including the average per cent accuracy in IT and DT, and the answering speed in the IT. The data of answering speed was the time that the participants spent on answering questions from the start time of the question to the time of the answer that were chosen. The second part is the results of the post-test online survey. The third part is the record of participants' spontaneous comments during the test and suggestions after the test. The results of the memory test were analysed statistically, including descriptive statistics and inferential statistics.

The differences and associations between samples were analysed. According to the distributions of the data, the dependent *t*-test is a parametric test used to compare differences between groups that the same participants experienced the two conditions, while the Wilcoxon Signed-Rank (WSR) test is the non-parametric equivalent of the dependent *t*-test (Field and Hole, 2002). If the *p*-value is larger than 0.05, the two or more than two groups of data are not significantly different. If the *p*-value is smaller than 0.05, the two or more than two groups of data are significantly different.

Pearson's correlation coefficient, also known as r or Pearson's r, is the test to measure the statistical linear associations between two continuous variables. If Pearson's r is from 0 to 1, this indicates a positive relationship. If Pearson's r is from 0 to -1, this indicates a negative relationship (Allua and Thompson, 2009). Parametric tests are used for data of normal distribution while non-parametric tests are used for data of non-normal distribution. If the *p*-value of the Shapiro-Wilk (SW) test is larger than 0.05, the data is normal distribution, otherwise, the data is a non-normal distribution (Field and Hole, 2002).

In this study, the SW test was conducted firstly to study the distribution of the data. If the data was normal distribution, the dependent *t*-test was used to compare differences among samples. If the data was non-normal distribution, the WSR test was used to compare the differences between samples. The Pearson's r was used to assess the relationships between samples.

5.4.2.1 The results of the accuracy and the answering speed in the memory test in Study 3

The results of the memory test are presented as the MRQ, RRQ and PRQ individually. The results showed that different VIs had different effectiveness for Reading & Memorising SRs. The results rejected the null hypothesis. Table 5-13 shows the results of average per cent accuracy of the **MRQs** and the results of the WSR test for comparing samples B1, B2, B3, B4 and B5. The results of the SW test of the MRQs (Table 5-13) showed that all the average per cent accuracy was non-normal distribution, as the *p*-value was smaller than 0.05. Therefore, the WSR test (non-parametric) was used to compare the differences among samples.

Table 5-13. The results of average per cent accuracy of MRQs and the results of WSR test for comparing samples B1, B2, B3, B4 and B5 in Study 3.

MRQ	**Sample**	**Accuracy**	**SD**	**SW test**	**Compare samples** (WSR test)			
Average per cent accuracy in IT	B1	58%	26%	p = 0.019	B1-B2 p = 0.131	B1-B3 p = 0.000	B1-B4 p = 0.001	B1-B5 p = 0.000
	B2	69%	29%	p = 0.002	B2-B3 p = 0.000	B2-B4 p = 0.030	B2-B5 p = 0.001	
	B3	94%	11%	p = 0.000	B3-B4 p = 0.013	B3-B5 p = 0.248		
	B4	83%	23%	p = 0.000	S4-S5 p = 0.048			
	B5	91%	15%	p = 0.000				
Average per cent accuracy in DT	B1	60%	26%	p = 0.002	B1-B2 p = 0.311	B1-B3 p = 0.000	B1-B4 p = 0.002	B1-B5 p = 0.000
	B2	64%	23%	p = 0.004	B2-B3 p = 0.000	B2-B4 p = 0.013	B2-B5 p = 0.000	
	B3	88%	23%	p = 0.000	B3-B4 p = 0.064	B3-B5 p = 0.747		
	B4	78%	27%	p = 0.000	B4-B5 p = 0.022			
	B5	90%	16%	p = 0.000				

Note: DT = Delayed Test; MRQ = Meaning Recall Question; SD = Standard Deviation; SW test = Shapiro-Wilk; IT = Immediate Test; WSR test = Wilcoxon Signed-Rank test

The **average per cent accuracy in the IT** of the MRQs showed that B1 (58%) and B2 (69%) were not significantly different ($p = 0.131 > 0.05$). The accuracy of B3 (94%), B4 (83%) and B5 (91%) were all significantly higher than B1 (58%) and B2 (69%), as all the *p*-values were smaller than 0.05 (refers to Table 5-13). The accuracy of B3 and B5 were significantly higher than B4 ($p_{B3\text{-}B4} = 0.013 < 0.05$, $p_{B4\text{-}B5} = 0.048 < 0.05$). The accuracy of B3 and B5 had no significant differences ($p_{B3\text{-}B5} = 0.248 > 0.05$).

The **average per cent accuracy in the DT** of the MRQs displayed that B1 (60%) and B2 (64%) were not significantly different ($p = 0.311 > 0.05$). B3 (88%), B4 (78%) and B5 (90%) were all significantly higher than B1 (60%) and B2 (64%), as all the *p*-values were smaller than 0.05 (refers to Table 5-13). The accuracy of B3 (88%) was not significantly higher than B4 (78%, $p_{B3\text{-}B4} = 0.064 > 0.05$) and not significantly lower than B5 (90%, $p_{B3\text{-}B5} = 0.747 > 0.05$). The accuracy of B5 (90%) was significantly higher than B4 (78%, $p_{B4\text{-}B5} = 0.022 < 0.05$).

Table 5-14 shows the difference (WSR test) and correlation (Pearson's r) between the MRQs' average per cent accuracy in the IT and DT. Comparing the accuracy between the IT and DT, they showed minor differences: $B1_{IT\ (58\%)} < B1_{DT\ (60\%)}$, $B2_{IT\ (69\%)} > B2_{DT\ (64\%)}$, $B3_{IT\ (94\%)} > B3_{DT\ (88\%)}$, $B4_{IT\ (83\%)} > B4_{DT\ (78\%)}$, $B5_{IT\ (91\%)} > B5_{DT\ (90\%)}$. The differences between the IT and DT of the five samples were not significant ($p_{B1} = 0.828$, $p_{B2} = 0.166$, $p_{B3} = 0.084$, $p_{B4} = 0.227$, $p_{B5} = 0.782 > 0.05$).

Table 5-14. The difference (WSR test) and correlation (Pearson's r) between MRQs' average per cent accuracy in IT and DT of samples B1, B2, B3, B4 and B5 in Study 3.

Sample	**Average per cent accuracy**		**Compare IT and DT** (WSR Test)	**Pearson's r**
B1	IT	58%	$p_{B1} = 0.828$	$r_{B1} = 0.129$ $p_{B1} = 0.496$
	DT	60%		
B2	IT	69%	$p_{B2} = 0.166$	$r_{B2} = 0.758$ $p_{B2} = 0.000$
	DT	64%		
B3	IT	94%	$p_{B3} = 0.084$	$r_{B3} = 0.470$ $p_{B3} = 0.009$
	DT	88%		
B4	IT	83%	$p_{B4} = 0.227$	$r_{B4} = 0.607$ $p_{B4} = 0.000$
	DT	78%		
B5	IT	91%	$p_{B5} = 0.782$	$r_{B5} = 0.415$ $p_{B5} = 0.023$
	DT	90%		

Note: DT = Delayed Test; MRQ = Meaning Recall Question; SD = Standard Deviation; SW test = Shapiro-Wilk; IT = Immediate Test; WSR test = Wilcoxon Signed-Rank test

As for the correlations, the Pearson's r showed that all accuracy in the IT had a positive ($0 < r < 1$) linear relationship with accuracy in the DT. Only the positive correlation between the IT and DT of B1 ($r_{B1} = 0.129$, $p_{B1} = 0.496 > 0.05$) was not significant, while the positive correlations of B2, B3, B4 and B5 were significant ($r_{B2} = 0.758$, $p_{B2} = 0.000 < 0.01$; $r_{B3} = 0.470$, $p_{B3} = 0.009 < 0.01$; $r_{B4} = 0.607$, $p_{B4} = 0.000 < 0.01$; $r_{B5} = 0.415$, $p_{B5} = 0.023 < 0.05$).

Table 5-15 shows the results of the average speed for answering the MRQs and the results of the WSR test for comparing samples B1, B2, B3, B4 and B5. The results of the SW test showed that only the answering speed of B4 was normal distribution ($p = 0.101 > 0.05$), hence, the WSR test (non-parametric) was used to compare the differences among samples.

Table 5-15. The results of the average speed for answering MRQs and the results of WSR test for comparing samples B1, B2, B3, B4 and B5 in Study 3.

MRQ	**Sample**	**Speed** (s)	**SD** (s)	**SW test**	**Compare samples** (WSR test)			
Average answering speed in IT	B1	26.1	10.0	*p* = 0.013	B1-B2 *p* = 0.022	B1-B3 *p* = 0.000	B1-B4 *p* = 0.000	B1-B5 *p* = 0.000
	B2	21.4	9.8	*p* = 0.007	B2-B3 *p* = 0.000	B2-B4 *p* = 0.000	B2-B5 *p* = 0.000	
	B3	10.5	4.5	*p* = 0.013	B3-B4 *p* = 0.001	B3-B5 *p* = 0.648		
	B4	14.2	4.6	*p* = 0.101	B4-B5 *p* = 0.011			
	B5	11.1	4.5	*p* = 0.034				

Note: MRQ = Meaning Recall Question; SD = Standard Deviation; SW test = Shapiro-Wilk; IT = Immediate Test; WSR test = Wilcoxon Signed-Rank test

The data of the **average answering speed in the IT** for the MRQs demonstrated that the answering speed of B1 (26.1s) was significantly slower than B2 (21.4s), B3 (10.5s), B4 (14.2s) and B5 (11.1s), as all the *p*-values of the WSR test were smaller than 0.05 (refers to Table 5-15). Similarly, the data of the answering speed of B2 (21.4s) was significantly slower than B3, B4 and B5 (all the *p*-values were smaller than 0.01). The speed of B4 (14.2s) was significantly slower than B3 (10.5s, $p_{B3\text{-}B4} = 0.001 < 0.01$) and B5 ($p_{B4\text{-}B5} = 0.011 < 0.05$), while B3 and B5 had no significant difference ($p_{B3\text{-}B5} = 0.648 > 0.05$).

Table 5-16 shows the correlation (Pearson's r) between the average per cent accuracy and average answering speed of the MRQs of samples B1, B2, B3, B4 and B5 in the IT. The Pearson's r displayed that all the accuracy in the IT had negative (-1 < r < 0) linear relationship with the speed. Only the negative linear relationships of B3 and B5 were significant (p_{B3} = 0.035 > 0.05, p_{B5} = 0.001> 0.05).

Table 5-16. The correlation (Pearson's r) between the average per cent accuracy and average answering speed of MRQs of samples B1, B2, B3, B4 and B5 in IT.

Sample	Accuracy and speed in IT		Pearson's r
B1	Accuracy	58%	r_{B1} = - 0.266 p_{B1} = 0.155
	Speed	26.1s	
B2	Accuracy	69%	r_{B2} = - 0.219 p_{B2}= 0.245
	Speed	21.4s	
B3	Accuracy	94%	r_{B3} = - 0.386 p_{B3} = 0.035
	Speed	10.5s	
B4	Accuracy	83%	r_{B4} = - 0.282 p_{B4} = 0.131
	Speed	14.2s	
B5	Accuracy	91%	r_{B5} = - 0.591 p_{B5} = 0.001
	Speed	11.1s	

Note: IT = Immediate Test

Table 5-17 shows the results of average per cent accuracy of the **RRQs** and the results of the WSR test for comparing samples B1, B2, B3, B4 and B5. The results of the SW test of the RRQs showed that all the average per cent accuracy was non-normal distribution, as the *p*-value was smaller than 0.05 (refers to Table 5-17). Therefore, the WSR test (non-parametric) was used to compare the differences among samples.

The **average per cent accuracy in the IT** of the RRQs showed that B1 (63%) was significantly lower than B2 (76%, p = 0.006 <0.05), B3 (94%, p = 0.000 < 0.01), B4 (88%, p = 0.001 < 0.01) and B5 (93%, p = 0.000 < 0.01), and the B2 was significantly lower than B3 (p = 0.000 < 0.01), B4 (p = 0.033 <0.05) and B5 (p = 0.000 < 0.01). The accuracy of B3 (94%), B4 (88%) and B5(93%) had no significant difference (p_{B3-B4} = 0.052 > 0.05, p_{B3-B5} = 0.763 > 0.05, p_{B4-B5} = 0.216 > 0.05).

The **average per cent accuracy in the DT** of the RRQs showed that B1 (54%) was significantly lower than B2 (78%, p = 0.000 <0.01), B3 (83%, p = 0.000 < 0.01), B4 (75%, p = 0.002 < 0.01) and B5 (85%, p = 0.000 < 0.01). The accuracy in the DT of B2, B3, B4 and B5 had no significant difference (p_{B2-B3} = 0.275 >0.05, p_{B2-B4} = 0.683 > 0.05, p_{B2-B5} = 0.061 > 0.05, p_{B3-B4} = 0.146 > 0.05, p_{B3-B5} = 0.592 > 0.05, p_{B4-B5} = 0.059 > 0.05). However, the p_{B2-B5} (0.061) value and the p_{B4-B5} (0.059) were close to 0.05; therefore, the accuracy of B5 (85%) was greater than B2 (78%) and B4 (75%) need to be paid more attention.

Table 5-17. The results of average per cent accuracy of RRQs and the results of WSR test for comparing samples B1, B2, B3, B4 and B5 in Study 3.

RRQ	**Sample**	**Accuracy**	**SD**	**SW test**	**Compare samples** (WSR test)			
Average per cent accuracy in IT	B1	63%	26%	*p* = 0.019	B1-B2 *p* = 0.006	B1-B3 *p* = 0.000	B1-B4 *p* = 0.001	B1-B5 *p* = 0.000
	B2	76%	19%	*p* = 0.000	B2-B3 *p* = 0.000	B2-B4 *p* = 0.033	B2-B5 *p* = 0.000	
	B3	94%	11%	*p* = 0.000	B3-B4 *p* = 0.052	B3-B5 *p* = 0.763		
	B4	88%	21%	*p* = 0.000	B4-B5 *p* = 0.216			
	B5	93%	13%	*p* = 0.000				
Average per cent accuracy in DT	B1	54%	27%	*p* = 0.005	B1-B2 *p* = 0.000	B1-B3 *p* = 0.000	B1-B4 *p* = 0.002	B1-B5 *p* = 0.000
	B2	78%	22%	*p* = 0.000	B2-B3 *p* = 0.275	B2-B4 *p* = 0.683	B2-B5 *p* = 0.061	
	B3	83%	23%	*p* = 0.000	B3-B4 *p* = 0.146	B3-B5 *p* = 0.592		
	B4	75%	29%	*p* = 0.000	B4-B5 *p* = 0.059			
	B5	85%	19%	*p* = 0.000				

Note: DT = Delayed Test; RRQ = Radical Recall Question; SD = Standard Deviation; SW test = Shapiro-Wilk; IT = Immediate Test; WSR test = Wilcoxon Signed-Rank test

Table 5-18 shows the difference (WSR test) and correlation (Pearson's r) between the RRQs' average per cent accuracy in the IT and DT of samples B1, B2, B3, B4 and B5. The accuracy in the DT showed no significantly difference with the accuracy in the IT of B1 (p_{B1} = 0.130 > 0.05) and B2 (p_{B2} = 0.686 > 0.05). The accuracy in the DT showed a significant decrease with the accuracy in the IT of B3 (p_{B3} = 0.005 < 0.01), B4 (p_{B4} = 0.012 < 0.05), and B5 (p_{B5} = 0.019 < 0.05). In terms of the correlations, the Pearson's r showed that all the accuracy in the IT had a significant positive linear relationship with the accuracy in the DT (0 < r < 1, *p* <0.05, refers to Table 5-18).

Table 5-18. The difference (WSR test) and correlation (Pearson's r) between RRQs' average per cent accuracy in IT and DT of samples B1, B2, B3, B4 and B5 in Study 3.

Sample	**Average per cent accuracy**		**Compare IT and DT** (WSR Test)	**Pearson's r**
B1	IT	63%	$p_{B1} = 0.130$	$r_{B1} = 0.375$ $p_{B1} = 0.041$
	DT	54%		
B2	IT	76%	$p_{B2} = 0.686$	$r_{B2} = 0.403$ $p_{B2} = 0.027$
	DT	78%		
B3	IT	94%	$p_{B3} = 0.005$	$r_{B3} = 0.466$ $p_{B3} = 0.009$
	DT	83%		
B4	IT	88%	$p_{B4} = 0.012$	$r_{B4} = 0.514$ $p_{B4} = 0.004$
	DT	75%		
B5	IT	93%	$p_{B5} = 0.019$	$r_{B5} = 0.447$ $p_{B5} = 0.013$
	DT	85%		

Note: DT = Delayed Test; IT = Immediate Test; WSR test = Wilcoxon Signed-Rank test

Table 5-19 shows the results of the average speed for answering the RRQs and the results of the WSR test for comparing samples B1, B2, B3, B4 and B5. The results of the SW test showed that only the answering speed of B2 was normal distribution (p = 0. 373 > 0.05), hence, the WSR test (non-parametric) was used to compare the differences among samples.

Table 5-19. The results of the average speed for answering RRQs and the results of WSR test for comparing samples B1, B2, B3, B4 and B5 in Study 3.

RRQ	**Sample**	**Speed** (s)	**SD** (s)	**SW Test**	**Compare Samples** (WSR test)			
Average Answering Speed in IT	B1	25.3	13.0	$p = 0.000$	B1-B2 $p = 0.193$	B1-B3 $p = 0.000$	B1-B4 $p = 0.000$	B1-B5 $p = 0.000$
	B2	20.1	6.9	$p = 0.373$	B2-B3 $p = 0.000$	B2-B4 $p = 0.000$	B2-B5 $p = 0.000$	
	B3	11.4	4.8	$p = 0.040$	B3-B4 $p = 0.171$	B3-B5 $p = 0.349$		
	B4	13.2	8.0	$p = 0.000$	B4-B5 $p = 0.011$			
	B5	10.2	5.5	$p = 0.001$				

Note: RRQ = Radical Recall Question; SD = Standard Deviation; SW test = Shapiro-Wilk; IT = Immediate Test; WSR test = Wilcoxon Signed-Rank test

The data of the **average answering speed in the IT** for the RRQs (Table 5-19) showed that B1 (25.3s) and B2 (20.1s) had no significant (p = 0.193 > 0.05) difference. The speed of B1 (25.3s) and B2 (20.1s) were significantly slower (longer time) than B3 (11.4s), B4 (13.2s) and B5 (10.2s), as all the p-values of WSR test were smaller than 0.001. Compared with the speed, B3, B4 and B5 all showed no significant difference ($p_{B3-B4} = 0.171 > 0.05$, $p_{B3-B5} = 0.349 > 0.05$). The speed of B5 was significantly faster than B4 ($p_{B4-B5} = 0.011 < 0.05$).

Table 5-20 shows the correlation (Pearson's r) between the average per cent accuracy and average answering speed of the RRQs of samples B1, B2, B3, B4 and B5 in the IT. The Pearson's r showed that all the accuracy in the IT had a negative ($-1 < r < 0$) linear relationship with the speed. The negative relationships for B1, B2 and B3 were significant (*p*-values are smaller than 0.05).

Table 5-20. The correlation (Pearson's r) between the average per cent accuracy and average answering speed of RRQs of samples B1, B2, B3, B4 and B5 in IT.

Sample	Accuracy and speed in IT		Pearson's r
B1	Accuracy	63%	$r_{B1} = -0.437$ $p_{B1} = 0.016$
	Speed	25.3s	
B2	Accuracy	76%	$r_{B2} = -0.371$ $p_{B2} = 0.044$
	Speed	20.1s	
B3	Accuracy	94%	$r_{B3} = -0.453$ $p_{B3} = 0.012$
	Speed	11.4s	
B4	Accuracy	88%	$r_{B4} = -0.210$ $p_{B4} = 0.265$
	Speed	13.2s	
B5	Accuracy	93%	$r_{B5} = -0.348$ $p_{B5} = 0.059$
	Speed	10.2s	

Note: IT = Immediate Test

Table 5-21 shows the results of average per cent accuracy of the **PRQs** and the results of the WSR test for comparing samples B1, B2, B3, B4 and B5 in Study 3. The results of the normality SW test for the data of speed for the PRQs showed that all the data were non-normal distribution (all the *p*-values of the SW test were smaller than 0.05). Therefore, the WSR test was conducted for comparing the five samples.

The **average per cent accuracy in the IT** of the PRQs showed that B1 (44%) was significantly lower than B2 (78%), B3 (78%), B4 (69%) and B5 (92%), as all the *p*-values were smaller than 0.01 (refers to Table 5-21). The accuracy in the IT of B2 had no significant difference with B3 and B4 ($p_{B2-B3} = 0.948 > 0.05$, $p_{B2-B4} = 0.095 > 0.05$). The accuracy in the IT of B3 was significantly higher than B4 ($p_{B3-B4} = 0.038 < 0.05$). The accuracy of B5 was significantly higher than B2 ($p_{B2-B5} = 0.001 < 0.01$), B3 ($p_{B3-B5} = 0.015 < 0.05$) and B4 ($p_{B4-B5} = 0.001 < 0.01$).

Table 5-21. The results of average per cent accuracy of PRQs and the results of WSR test for comparing samples B1, B2, B3, B4 and B5 in Study 3.

PRQ	Sample	Accuracy	SD	SW test	Compare samples (WSR test)			
Average per cent accuracy in IT	B1	44%	24%	$p = 0.010$	B1-B2 $p = 0.000$	B1-B3 $p = 0.000$	B1-B4 $p = 0.001$	B1-B5 $p = 0.000$
	B2	78%	19%	$p = 0.000$	B2-B3 $p = 0.948$	B2-B4 $p = 0.095$	B2-B5 $p = 0.001$	
	B3	78%	26%	$p = 0.000$	B3-B4 $p = 0.038$	B3-B5 $p = 0.015$		
	B4	69%	31%	$p = 0.001$	B4-B5 $p = 0.001$			
	B5	92%	12%	$p = 0.000$				
Average per cent accuracy in DT	B1	51%	26%	$p = 0.005$	B1-B2 $p = 0.003$	B1-B3 $p = 0.000$	B1-B4 $p = 0.001$	B1-B5 $p = 0.000$
	B2	73%	24%	$p = 0.001$	B2-B3 $p = 0.040$	B2-B4 $p = 0.939$	B2-B5 $p = 0.197$	
	B3	84%	21%	$p = 0.000$	B3-B4 $p = 0.017$	B3-B5 $p = 0.451$		
	B4	72%	30%	$p = 0.000$	B4-B5 $p = 0.274$			
	B5	80%	19%	$p = 0.000$				

Note: PRQ = Position Recall Question; SD = Standard Deviation; SW test = Shapiro-Wilk; IT = Immediate Test; WSR test = Wilcoxon Signed-Rank test

The **average per cent accuracy in the DT** of the PRQs showed that B1 (51%) was significantly lower than B2 (73%), B3 (84%), B4 (72%) and B5 (80%), as all the *p*-values were smaller than 0.01 (refers to Table 5-21). The accuracy in the DT of B3 was significantly higher than B2 ($p_{B2\text{-}B3} = 0.040 < 0.05$) and B4 ($p_{B3\text{-}B4} = 0.017 < 0.05$). The accuracy in the DT of B5 had no significant difference with B3 ($p_{B3\text{-}B5} = 0.451 > 0.05$) and B4 ($p_{B4\text{-}B5} = 0.274 > 0.05$).

Table 5-22 shows the difference (WSR test) and correlation (Pearson's r) between the PRQs' average per cent accuracy in IT and DT. The accuracy in the DT showed no significantly difference with the accuracy in the IT of B1 ($p = 0.172 > 0.05$), B2 ($p = 0.340 > 0.05$), B3 ($p = 0.265 > 0.05$), B4 ($p = 0.412 > 0.05$). The accuracy in DT showed a significant decrease with the accuracy in the IT of B5 ($p = 0.005 < 0.01$). In terms of the correlations, the Pearson's r showed that all the IT accuracy had a positive linear relationship ($0 < r < 1$, refers to Table 5-22) with the DT accuracy. The correlations of B1, B3 and B4 were significant ($p_{B1} = 0.035 < 0.05$, $p_{B3} = 0.024 < 0.05$, $p_{B4} = 0.000 < 0.01$).

Table 5-22. The difference (WSR test) and correlation (Pearson's r) between PRQs' average per cent accuracy in IT and DT of samples B1, B2, B3, B4 and B5 in Study 3.

Sample	**Average per cent accuracy**		**Compare IT and DT** (WSR Test)	**Pearson's r**
B1	IT	44%	$p_{B1} = 0.172$	$r_{B1} = 0.386$ $p_{B1} = 0.035$
	DT	51%		
B2	IT	78%	$p_{B2} = 0.340$	$r_{B2} = 0.107$ $p_{B2} = 0.575$
	DT	73%		
B3	IT	78%	$p_{B3} = 0.265$	$r_{B3} = 0.410$ $p_{B3} = 0.024$
	DT	84%		
B4	IT	69%	$p_{B4} = 0.412$	$r_{B4} = 0.697$ $p_{B4} = 0.000$
	DT	72%		
B5	IT	91%	$p_{B5} = 0.005$	$r_{B5} = 0.283$ $p_{B5} = 0.129$
	DT	80%		

Note: DT= Delayed Test; IT = Immediate Test; WSR test = Wilcoxon Signed-Rank test

Table 5-23 shows the results of the average speed for answering the PRQs and the results of the WSR test or the *t*-test. The results of the normality SW test showed that B2 ($p = 0.511 > 0.05$), B3 ($p = 0.051 > 0.05$), and B4 ($p = 0.052 > 0.05$) were normal distribution while all the other data of speed and accuracy were non-normal distribution. Therefore, the WSR test was used for comparing non-normal distribution data and the *t*-test was used for comparing normal distribution data. The *p*-values of the WSR test were shown as p_w and *p*-values of the *t*-test were shown as p_t in Table 5-23.

Table 5-23. The results of the average speed for answering PRQs and the results of WSR test or *t*-test for comparing samples B1, B2, B3, B4 and B5 in Study 3.

PRQ	**Sample**	**Speed** (s)	**SD** (s)	**SW Test**	**Compare Samples** (WSR or *t*-test)			
Average answering speed in IT	B1	22.4	9.7	$p = 0.023$	B1-B2 $p_w = 0.000$	B1-B3 $p_w = 0.000$	B1-B4 $p_w = 0.000$	B1-B5 $p_w = 0.000$
	B2	15.0	4.6	$p = 0.511$	B2-B3 $p_t = 0.048$	B2-B4 $p_t = 0.530$	B2-B5 $p_w = 0.034$	
	B3	13.1	5.5	$p = 0.051$	B3-B4 $p_t = 0.352$	B3-B5 $p_w = 0.885$		
	B4	14.3	5.4	$p = 0.052$	B4-B5 $p_w = 0.321$			
	B5	12.9	4.2	$p = 0.000$				

Note: PRQ = Position Recall Question; SD = Standard Deviation; SW test = Shapiro-Wilk; p_t = *p*-values of *t*-test; p_w = *p*-values of WSR test; IT = Immediate Test; WSR test = Wilcoxon Signed-Rank test

The data of the **average answering speed in the IT** for the PRQs showed that B1 (22.4s) was significantly slower than B2 (15.0s), B3 (13.1s), B4 (14.3s) and B5 (12.9s), as all the *p*-values were smaller than 0.01 (Table 5-23). The speed of B2 was significantly slower than B3 ($p_{t.B2-B3} = 0.048 < 0.05$) and B5 ($p_{w.B2-B5} = 0.034 < 0.05$) but not significantly slower than B4 ($p_{t.B2-B4} = 0.530 > 0.05$). The speed of B3, B4 and B5 had no significant difference ($p_{t.B3-B4} = 0.352 > 0.05$, $p_{w.B3-B5} = 0.885 > 0.05$, $p_{w.B4-B5} = 0.321 > 0.05$).

Table 5-24 shows the correlation (Pearson's r) between the accuracy and answering speed of the PRQs in IT. The Pearson's r showed that all the accuracy in the IT had a negative ($-1 < r < 0$) linear relationship with the speed. The negative relationships of B1, B2 and B3 were significant (all *p*-values were smaller than 0.05). The correlations between the accuracy and the speed for answering the PRQs in the IT were not consistent. The data showed a positive but not significant correlations of B1 ($r_{B1} = 0.092$, $p_{B1} = 0.630 > 0.05$), B2 ($r_{B2} = 0.018$, $p_{B2} = 0.925 > 0.05$) and B5 ($r_{B5} = 0.006$, $p_{B5} = 0.976 > 0.05$). The *p*-values of B1, B2 and B5 were very large, especially the p_{B2} (0.925) and the p_{B5} (0.976) were close to 1, which meant that the positive correlations were very weak. The correlations between the accuracy and the speed of B3 ($r_{B3} = -0.659$) and B4 ($r_{B4} = -0.079$) were negative, but only the negative correlation for B3 was significant ($p_{B3} = 0.000 < 0.01$).

Table 5-24. The correlation (Pearson's r) between the average per cent accuracy and average answering speed of PRQs of samples B1, B2, B3, B4 and B5 in IT.

Sample	**Accuracy and speed in IT**		**Pearson's r**
B1	Accuracy	44%	$r_{B1} = 0.092$ $p_{B1} = 0.630$
	Speed	22.4s	
B2	Accuracy	78%	$r_{B2} = 0.018$ $p_{B2} = 0.925$
	Speed	15.0s	
B3	Accuracy	78%	$r_{B3} = -0.659$ $p_{B3} = 0.000$
	Speed	13.1s	
B4	Accuracy	69%	$r_{B4} = -0.079$ $p_{B4} = 0.677$
	Speed	14.3s	
B5	Accuracy	91%	$r_{B5} = 0.006$ $p_{B5} = 0.976$
	Speed	12.9s	

Note: IT = Immediate Test

In summary, the results of the **MRQs** showed how the participants remembered the meanings of the 20 SRs by using the five samples. The main findings were:

- **Accuracy in the IT**: B1 and B2 had no significant difference; B1 and B2 had significantly lower accuracy than B3, B4 and B5; B3 and B5 had no significant difference; B3 and B5 had significantly higher accuracy than B4.
- **Accuracy in the DT**: B1 and B2 had no significant difference; B1 and B2 had significantly lower accuracy than B3, B4 and B5; B5 had significantly higher accuracy than B4; B3 had no significant difference with B4 and B5.
- **Answering speed in the IT**: participants answered MRQs of B1 with a significant slower speed than B2; participants also answered MRQs of B1 and B2 with significantly slower speeds than B3, B4 and B5. The answering speed of B3 and B5 had no significant difference. Participants answered MRQs of B3 and B5 with significantly faster speeds than B4.
- **Relationships between the accuracy in the IT and the DT**: B1, B2, B3, B4 and B5 had no significant difference in term of their accuracy in the IT and the DT; B2, B3, B4 and B5 had a significantly positive correlation between their accuracy in the IT and the DT; B1 had a positive but not significant correlation between its accuracy in the IT and the DT.
- **Correlations between the accuracy and the answering speed in the IT**: B3 and B5 had significantly negative correlations between their IT accuracy and answering speed; B1, B2 and B4 had negative but not significant correlations between their accuracy and answering speed in the IT.

The results of the **RRQs** showed how the participants remembered the shapes of the 20 SRs by using the five samples. The main findings were:

- **Accuracy in the IT**: B1 had significantly lower accuracy than B2, B3, B4 and B5; B2 had significantly lower accuracy than B3, B4 and B5; B3, B4 and B5 had no significant difference.
- **Accuracy in the DT**: B1 had significantly lower accuracy than B2, B3, B4 and B5; B2, B3, B4 and B5 had no significant difference.
- **Answering speed in the IT**: B1 and B2 had no significant difference. Participants answered RRQs of B1 and B2 with significantly slower speeds than B3, B4 and B5. The answering speed of B3 had no significant difference with B4 and B5. Participants answered RRQs of B4 with a significantly slower speed than B5.
- **Relationships between the accuracy in the IT and the DT**: B1 and B2 had no significant difference in term of their accuracy in the IT and the DT; B3, B4 and B5 had a significant decrease from the

accuracy in the IT to the DT; B1, B2, B3, B4 and B5 had significant positive correlations between their accuracy in the IT and the DT.

- **Correlations between the accuracy and the answering speed in the IT**: B1, B2 and B3 had significant negative correlations between their accuracy and speed in the IT; B4 and B5 had negative but not significant correlations between their accuracy and speed in the IT.

In summary, the accuracy of the **PRQs** showed how the participants remembered the positions of the 20 SRs with five samples. The main findings were:

- **Accuracy in the IT**: B1 had significantly lower accuracy than B2, B3, B4 and B5; B2 had no significant difference with B3 and B4; B3 had significantly higher accuracy than B4; B5 had significantly higher accuracy than B2 and B4.
- **Accuracy in the DT**: B1 had significantly lower accuracy than B2, B3, B4 and B5; B3 had significantly higher accuracy than B2 and B4; B5 had no significant difference with B3 and B4.
- **Answering speed in the IT**: participants answered PRQs of B1 with a significantly slower speed than B2, B3, B4, B5. Participants answered PRQs of B2 with a significantly slower speed than B3 and B5; B2 and B4 had no significant difference; B3, B4 and B5 had no significant difference.
- **Relationships between accuracy in the IT and the DT**: B1, B2, B3 and B4 had no significant difference in term of their accuracy in the IT and the DT; B5 had a significant decrease from the accuracy in the IT to the DT; B1, B3 and B4 had significant positive correlations between their accuracy in the IT and the DT; B2 and B5 had positive but not significant correlations between their accuracy in the IT and the DT.
- **Correlations between accuracy and answering speed in the IT**: B3 had a significant negative correlation between the IT accuracy and speed; B4 had negative but not significant correlations between their accuracy and answering speed in the IT; B1, B2 and B5 had positive but not significant correlations between their accuracy and answering speed in the IT.

5.4.2.2 The results of the post-test online survey in Study 3

All the participants were asked to choose one from the five samples as the most effective VI for them to read and memorise SRs after DT. The results showed that none of the participants chose B1 or B2, 23% of the participants chose B3, 27% chose B4, and 50% chose B5.

Then, they were asked to scale how they agreed with the given functions of the integrated illustrations in B3, B4 and B5 and the colour coding in B2 and B5. For the functions of the integrated illustrations, most of the participants agreed that the integrated illustrations visualised the meanings of the SRs (23.3%: agree; 76.7%: strongly agree) and assisted to memorise the shapes of the SRs (10%: agree; 83.3%: strongly agree).

In regard to the functions of colour coding, most of the participants agreed that colour coding assisted to memorise the positions of the SRs (36.7%: agree; 50%: strongly agree), split the compound CCs into parts (36.7%: agree; 43.3%: strongly agree), and highlight the SRs in the compound CCs (26.7%: agree; 53.3%: strongly agree).

5.4.2.3 The results of the participants' spontaneous comments and suggestions in Study 3.

The results of the participants' spontaneous comments during testing and suggestions after testing were recorded. The key viewpoints are stated as follows.

First, **the integrated illustration was an effective VI for the acquisition of Chinese SRs, especially for recalling meanings and shapes**. The participants indicated that the SRs displayed with integrated illustrations were easier to memorise. 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.' S3P3 said. 'I feel there is a strong association with visuals, I like the visual stimulated for learning Chinese. I like the way you put the illustrations under the radicals.' S3P10 said. Many participants expressed a more direct opinion, like S3P4 said, 'I feel the walk, bird, fire and grass radicals are very easy to remember.' and S3P20 said, 'I can't remember the cloth, wood and shell radicals.' They stated that the SRs with illustrations were easier to recall than the SRs without illustrations.

Second, **colour coding was an effective learning method for the acquisition of Chinese SRs, especially for memorising positions.** For example, 'The colour coding, you try to link the colour and the position, is very help for me.' S3P15 said. Regarding the combinations (B4 and B5) of illustrations and the colour coding, 15 participants stated that the colour-coded illustrations (B5) was the easiest to remember, since they chose B5 in the post-test survey. However, three participants did not show a clear preference. For example, S3P26 said, 'For the illustration and colour coding, I don't mind working with two different colours, I just remember the meaning from the illustration and remember the colour coding positions separately. I just don't think which one is better or worse (B4 and B5), both okay for me.'

Third, as for suggestions and comments, participants S3P17 and S3P24 mentioned the brown colour for the bottom position (colour coding) were not very obvious and a bit dark, especially when it was showed with SRs in black colour. Participants S3P6 and S3P29 spontaneously commented during the test that the SR Walk (辶) and the SR Shelter (广) informed their positions by their own shapes. Therefore, the colour of the colour coding needed to be reconsidered, especially the brown colour. The SR Walk (辶) and the SR Shelter (广) should be removed in further experimental study.

5.4.3 Discussion

Study 3 examined the VIs for Reading & Memorising SRs. The results showed that the integrated illustrations and the colour coding had significant effects on memorising after reading the Chinese SRs, which rejected the null hypothesis.

The five samples had identical layout, the same size of SRs and CCs, and identical number of strokes as a group of SRs. Comparing samples B1 and B2, the only difference in terms of the VIs was that B2 had the colour coding on SRs, while B1 did not. The effect of colour coding could be examined by comparing the results of B1 and B2. Comparing B1 and B3, the only difference was that B3 had the integrated illustrations, while B1 did not. The impact of the integrated illustrations could be tested by comparing the results of B1 and B3. B4 was a simple aggregated of the illustrations (B3) and the colour coding (B2). B5 was the colour-coded integrated illustration. Comparing B4 and B5, the only difference was the colour of illustrations.

The results of the IT and DT showed how participants remembered the SRs with the five samples in the IT and DT. As the instructional goals of this study were memorising the meanings, shapes and positions of the SRs, the effect of the colour coding and integrated illustrations was discussed according to the three goals with the results of MRQs, RRQs and PRQs.

The effect of the colour coding: the results of comparing B1 and B2 showed that the colour coding did not influence the accuracy of memorising the meanings (MRQs) of the SRs, in both IT and DT. But participants answered the **MRQs** with a significantly faster speed. The significant time difference of answering B1 and B2 was 4.7 seconds for answering the four MRQs. To be more specific, participants spent 1.175 seconds less on answering an MRQ of B2 than B1. The results showed the colour coding brought a significant increase in accuracy, for memorising the shapes of the SRs (**RRQs**) (B1: 63%, B2:76% in the IT; B1: 54%, B2: 78% in the DT). Although the colour coding was designed for highlighting and memorising the positions of the SRs, the chromatic colour highlighted the shapes of SRs. Compared the achromatic colour in B1, the SRs presented in chromatic colour in B2 were more visually attractive and easier to remember. The participants spent around five seconds shorter time on answering the four RRQs of B2 than B1, but the difference was not significant. The effect of colour for memorising shapes of SRs could be explained that colour increased attention and enhanced memory of the VIs (Winn, 1993; Mijksenaar, 1997; Pettersson, 1998; 2010; 2019; Olurinola and Tayo, 2015). The results of the **PRQs** showed that the colour coding made a significant increase of the accuracy in the IT (B1: 44%, B2: 78%) and DT (B1: 51%, B2:73%). The participants answered the four PRQs of B2 with a significantly faster speed (about seven seconds shorter time) than B1. The results of the PRQs were consistent with the literature review, that colour coding was a useful tool for enhancing memory in instructions (Peck and Hannafin, 1988; Bradshaw, 2003; Samara, 2007; Pettersson, 2013c; 2015a; 2015b). The accuracy in the DT and the IT of B2 did not show a significant difference, in terms of the RRQs and PRQs. This meant of the effect of colour coding for memorising the shapes and the positions of the SRs could stay at least seven days without a review. Additionally, the results of the post-test survey and the participants' comments reconfirmed the effect of the colour coding for enhancing learning the SRs.

The effect of the integrated illustrations: the results of comparing B1 and B3 showed that the integrated illustration made a significant increase for memorising meanings (**MRQ**s) of the SRs (B1: 58%, B3: 94% in the IT) (B1: 60%, B3: 88% in the DT). The participants answered the four MRQs of B3 with a significantly faster speed (about 16 seconds shorter time) than B1, which was faster than effect caused by the colour coding (about five seconds shorter time). For answering the **RRQ**s, the integrated illustrations made a significant increase for memorising the shapes of SRs (B1: 63%, B3: 94% in the IT) (B1: 54%, B3: 83% in the DT). The participants answered the four PRQs of B3 with a significant faster speed (about 14 seconds shorter time) than B1. In regard to the **PRQ**s, the integrated illustrations also improved the accuracy (B1: 44%, B3: 78% in the IT; B1: 51%, B3: 84% in the DT). The answering speed significantly increased from 22.4s of B1 to 13.1s of B3 for answering the four PRQs. The findings were in line with the cognitive load theory that integration of multiple information increased the effect of VIs and was easy to remember (Chandler and Sweller, 1996; Ayres and Sweller, 2005; Sadoski and Paivio, 2013) and the illustration enhanced memory and visualised texts (Szlichcinski, 1980; Gombrich, 1990; Horn, 1998; Male, 2017; Samara, 2007; Hall, 2011). Moreover, the results showed that the accuracy in the IT and DT for memorising meanings and positions had no significant difference, which meant the effect of the integrated illustrations for memorising meanings and positions could stay long (at least seven days). However, the high accuracy of B3 for memorising the shapes of the SRs had a significant decrease from 94% in IT to 83% in the DT. The results meant that the effect of the integrated illustrations for memorising the shapes of SRs could not stay as long as the effect of memorising meanings and positions. Moreover, the results of the post-test survey and the participants' comments also suggested that the integrated illustrations enhanced learning SRs.

The effect of the combinations of the illustrations and the colour coding: the comparisons between B4 and B5 showed which combinations of the illustrations and colour coding worked better for enhancing learning the SRs. The results of the accuracy showed that B5 had a significantly higher accuracy than B4 for memorising meanings of SRs (**MRQs**) (B4: 83%, B5: 91% in the IT; B4: 78%, B5: 90% in the DT). The participants answered the MRQs of B5 (11.1s) with a faster speed than B4 (14.2s). The accuracy in IT and DT for both B4 and B5 had no significant difference, which meant that the effects of B4 and B5 were stable. Hence, the colour-coded integrated illustrations (B5) had significantly better effectiveness for memorising meanings of SRs than the simple aggregated combination of colour coding and illustrations (B4). The results of the **RRQs** showed that B5 had higher (not significantly) accuracy than B4 of the accuracy (B4: 88%, B5: 93%) in the IT and the accuracy (B4:75%, B5: 85%) in the DT. The accuracy in the DT of B4 and B5 both had a significant decrease, compared to their accuracy in the IT. It indicated that the effect of B4 and B5 for memorising the shapes of SRs has been reduced to some extent after a few days. However, the difference between B4 (75%) and B5 (85%) was nearly significant (p = 0.059) in the DT, which implied that the effectiveness of B5 was stronger than B4 in the DT. Therefore, for memorising shapes of SRs, although the difference between B4 and B5 was not significant, B5 still had a better effect than B4. Regarding the effects of learning the positions of the SRs (**PRQs**), the results of accuracy in the IT showed that B5 (91%) was significantly higher B4 (69%). However, the high accuracy of B5 (91%) in IT for answering four PRQs had a significantly decline to 80% of the accuracy in the DT. The participants answered the PRQs of B5 (12.9s) with a faster speed than that of B4 (14.3s), but not significantly. Similar to the results of the RRQs, B5 was more effective than B4 for memorising the positions of SRs.

The results of B3 and B5 showed high effectiveness for learning SRs for the three instructional goals. The comparison results showed that B3 and B5 had no significant difference in the accuracy for memorising the meanings (MRQs) and the shapes (RRQs) of SRs in both IT and DT. The results also demonstrated that B3 and B5 had no significant difference in the answering speed of the MRQs and PRQs. However, for memorising the positions (PRQs) of SRs, B5 (91%) had a significant higher accuracy in the IT than B3 (78%). There was no significant difference between B3 and B5 of the accuracy in the DT and the speed in the IT and the DT.

Therefore, **the colour-coded integrated illustrations in B5 had the highest effectiveness among the other four samples, in terms of memorising the meanings, shapes and positions of the SRs. The integrated illustrations in B3 had the second-highest effectiveness.** The difference between B3 and B5 was that B5 brought a significant higher accuracy in memorising positions of SRs than B3 in the IT. For the others, the statistical results of B3 and B5 showed no significant difference. Both of B3 and

B5 had high accuracy and fast speed for answering questions, which were regarded as high effectiveness. The accuracy of the three questions for B5 in the IT all had significant negative correlations with answering speed, which indicated that the higher accuracy the participants had, the faster speed the participants used to answer the questions. Regarding the participants' opinions, only 23% of the participants chose B3 was the easiest sample, while 50% of the participants chose B5. The effect of B3 and B5 would be further tested in the following experimental study.

The simple aggregated illustrations and the colour coding in B4 resulted in lower effectiveness than B3 and B5. The reason might be that the simple aggregated design increased the memory load. The design principles suggested not to mix using colour coding and decorative colour together, which would cause confusion and misunderstanding (Pettersson, 2010; 2014).

Although it was known that mixed using colour coding and decorative colour would cause confusion and misunderstanding, there were two reasons that B4 was tested in Study 3. First, the design principle of not mixed using colour coding and the decorative colour was understood as presenting different information with colour coding in one page, rather than using colour coding for memorising. Only one colour from the colour coding was presented on one page with the decorative colour. Second, the participants in Study 2 stated they did not feel difficult to work with different colours. Hence, B4 was kept in Study 3. However, the results showed that mixed using colour coding and decorative colour for memorising had a low effectiveness. Therefore, B4 was not further tested in the following experiment.

The effects of the colour coding and the integrated illustrations were examined and confirmed. They showed high effectiveness for memorising the meanings, shapes and positions of the SRs. The effect for memorising meanings was long-lasting while the effect for memorising shapes and positions was not always long-lasting. However, the colour coding and the integrated illustrations showed significant benefits for memorising shapes and positions of SRs as long-term memory (at least seven days). The effect was not as good as short-term memory. This situation can be explained with two reasons. First, forgetting is nature for most people. Second, it was undeniable that different SRs might have different difficulties for different participants, though the difficulties of SRs were controlled by identical number of strokes. To minimise the effect of different SRs and still used the within-subjects study as a further experiment, the SRs would be shifted among samples in Study 5.

5.5 Conclusions

The study explored the effectiveness of different VIs for Reading & Memorising SRs by non-specialist beginners. Study 1 investigated existing cases and narrowed down the wide range of design elements and variables for reading and memorising SRs with the 30 participants. The integrated illustrations, instructional squares and colour coding in existing cases showed a potential effect for enhancing reading and memorising SRs.

Based on the results of Study 1 and the corresponding theoretical suggestions in the literature review, prototypes of VIs for Reading & Memorising SRs were developed. The prototypes had five samples, namely, A1, A2, A3, A4 and A5, which included different combinations of integrated illustrations, instructional squares and colour coding. Study 2 initially explored the effectiveness of the prototypes and refined them by two iterative usability tests with the 10 participants. The refined prototypes also have five samples (B1, B2, B3, B4 and B5). The five samples were used as materials in the experimental Study 3.

The quasi-experimental study in Study 1 and Usability Test 1 (in Study 2) tested VIs with paper-based materials. In order to control the study more rigorously, Usability Test 2 (in Study 2) and Study 3 tested VIs with digital-based materials.

Study 3 examined the effectiveness of the five samples (B1, B2, B3, B4 and B5) for Reading & Memorising SRs with 30 participants. Study 3 reported that the VIs with the colour coding significantly enhanced the memory of the shapes and positions of the SRs and the effect of the colour coding was long-lasting (at least seven days). The VIs with integrated illustrations significantly increased the memory of the meanings, shapes and positions of the SRs. The effects of the integrated illustrations for memorising the meanings and positions of the SRs were long-lasting, while the effect of memorising the shapes with illustrations had a significant decrease.

The colour coding and the integrated illustrations both brought a significant increase in memorising the shapes and positions of the SRs. The integrated illustrations had a significantly better accuracy in learning the meanings and shapes of the SRs. The colour coding and illustrations had similar effect for memorising the positions of the SRs. Therefore, the VIs with the colour coding only (B2) would be no longer tested in the further experiment. The VIs with the integrated illustrations (B3) and the colour-coded integrated illustrations (B5) showed similar high effectiveness for enhancing learning the SRs. The colour-coded illustrations (B5) showed a significant better accuracy in the IT for learning the positions of the SRs than B3. For answering the MRQs and the RRQs, samples B3 and B5 showed no significant difference.

The results of the survey also showed that sample B5 was more popular than B3. Considering a larger sample of SRs and the benefits of shifting different SRs among samples, B1(simple instructions), B3 (integrated illustrations) and B5 (colour-coded integrated illustrations) would be further explored. Moreover, to improve the sustainability of the effect, the design of the three samples would be adjusted, according to the design principles and the participants' suggestions.

The study not only confirmed the effectiveness of the integrated illustrations and the colour coding for enhancing learning the SRs by non-specialist beginners, but also concluded different functions by the post-test survey. It was agreed that the integrated illustrations could visualise meanings of SRs and assist to memorise shapes of SRs. The colour coding could help to memorise positions of SRs, split the compound CCs into parts and highlight SRs in compound CCs. Although the VIs with the colour coding only (B2) would be no longer tested, the functions of colour coding still worked with the integrated illustrations (B5).

6 Study of VIs for writing SRs

6.1 Introduction

This study aimed to explore the effectiveness of VIs for writing SRs by non-specialist beginners. This study was based on the findings of the literature review, visual survey and the interview in Chapters 3 and 4.

Accurately writing CCs simplifies and speeds up the writing process (Jaganathan and Lee, 2014; Zhang, 2014). SRs are essential parts of compound CCs (Shen and Ke, 2007; Xu et al., 2014). It is reasonable to point out the significance of accurately writing SRs, as writing SRs is an essential part of writing CCs. In the literature review (Section 3.2.3), a few studies explored the effectiveness of VIs for writing CCs accurately, especially static VIs. The visual survey in Section 4.3.2.2 showed that writing VIs have different design formats and elements.

Although the study of VIs for writing SRs was conducted after the study of VIs for Reading & Memorising SRs, they did not have a causal relationship with each other. Unlike the study of Reading & Memorising SRs in Chapter 5, the study of VIs for writing SRs was relatively small because of the limited variables of design elements in existing cases. Moreover, the literature review indicated clear suggestions, such as the use of colour and arrows.

This study started with a design development on the basis of design suggestions in the literature review and the existing cases in the visual survey in Chapter 4. Three samples were produced in the design development: samples C1, C2 and C3. Then, the experimental study was conducted to examine the effectiveness of the three samples for writing SRs.

6.2 Design development: VIs for writing SRs

According to the writing rules of CCs in the literature review (Section 3.2.1.2), CCs and SRs need to be written in accurate stroke order and stroke directions (National Language Committee, 1997; Jaganathan and Lee, 2014). Besides, it is reasonable that missing strokes should be avoided from accurately writing CCs and SRs. Otherwise, it is not a complete CC or a complete SR. Therefore, the

VIs aimed to facilitate non-specialist beginners to write complete SRs in accurate stroke order and directions.

The findings of the visual survey demonstrated that all-in-one and stroke-by-stroke presentations were the two main types of presentations in writing VIs. The stroke-by-stroke presentation was more popular than the all-in-one presentation in existing cases. Moreover, colour, line guides, numbers and arrows were used in the existing cases with different combinations. The findings of the literature review in Section 4.2.3 indicated that arrows are one of the most powerful visual elements for indicating directions and suggesting movements (Horton, 1993; Horn, 1998; Tversky et al., 2000; Pettersson, 2013c). Colour is suggested to draw attention and show different levels of information (Mijksenaar, 1997; Pettersson, 2019), which might be useful for showing stroke order.

To develop VIs for writing SRs, different types of lines guides, and typefaces were not be examined, since the previous research has shown clear suggestions. Figure 6-1 shows the chosen (blue highlighted) line guides and typefaces in developing writing VIs. For line guides, the results of the visual survey showed that most (eight of nine cases) of the existing cases used cross-shaped line guides (Style 1 and Style 2 in Figure 6-1) as backgrounds to show and standardise the position of SRs in the providing square rather than grid lines (Style 3 in Figure 6-1). Moreover, the cross-shaped line guides were also mentioned by teachers as ‘writing worksheets’ in the interview (Section 3.3.2.2). The line guide Style 1 has four lines, while the line guide Style 2 has two lines. Those two styles of line guides were both suggested by teachers who were interviewed in this study, and they had the same usage proportion of the existing cases in the visual survey (four cases each style). For writing complete CCs, the line guide Style 1 shows more accurate positions of strokes, since it has two diagonal lines. However, for writing SRs, it is more important to show the positions of SRs in squares. The line guide Style 2 presents the positions of SRs clear enough. The line guide Style 1 is more complicated, as it shows two more unnecessary lines for instructing writing SRs. It is against the simplicity principle (Dewar, 1999; Pettersson, 2010; 2014; Lipton, 2011). Therefore, the line guide Style 2 was chosen as the line guide background in design development for all samples.

Regarding typefaces (Figure 6-1), Kaiti typeface accounted for the largest proportion of existing cases in the visual survey rather than Songti and Heiti typefaces in writing VIs. Kaiti typefaces was also suggested by Zhang (2011) and teachers who were interviewed in this study. Therefore, Kaiti typeface was chosen in design development for all samples.

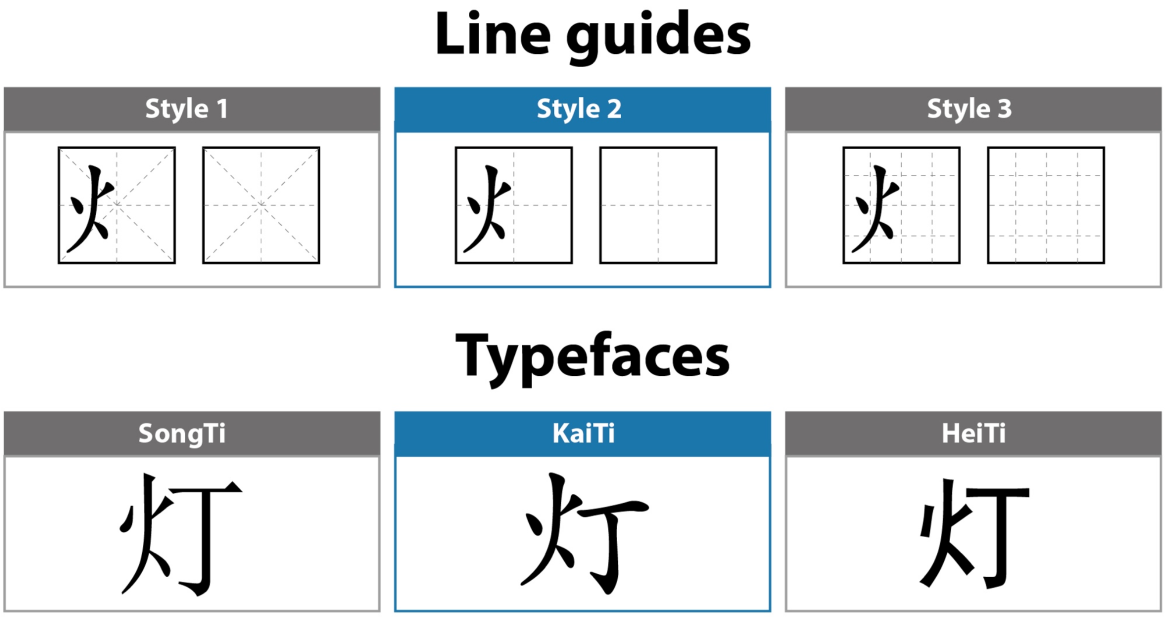


Figure 6-1. The chosen line guides and the typefaces (highlighted in blue) for developing VIs for writing SRs.

To investigate the effectiveness of different presentations (all-in-one presentation and stroke-by-stroke presentation), the use of arrows and colours, three samples were developed, namely C1, C2 and C3. Figure 6-2 shows the developed three samples of VIs with SR Fire as an example. C1 is the commonly used VIs in textbooks, displaying VIs for writing SRs without distinct colours and arrows in a stroke-by-stroke presentation.

Compared with C1, C2 had extra colour hints and arrows. In C2, each step that needed to be written was highlighted in red as colour hints. The black strokes are the strokes that have been written already and the other strokes are shown in light grey. Showing strokes in different colours for showing the hint of stroke order follows the contrast principle (Pettersson, 2014). To make the arrows distinct from SRs, the arrows were designed in blue rather than black, which followed the focal point principle (Chang et al., 2002; Lipton, 2011; Ali and Peebles, 2013; Pettersson, 2014; Lonsdale and Lonsdale, 2019).

C3 was the all-in-one presentation with arrows to show stroke directions and numbers to show stroke order. In C3, the arrows were placed inside each stroke to reduce the visual complexity, since placing many arrows around strokes in one picture may confuse people and cause visual fatigue (Barker and Fraser, 2004; Amare and Manning, 2016).

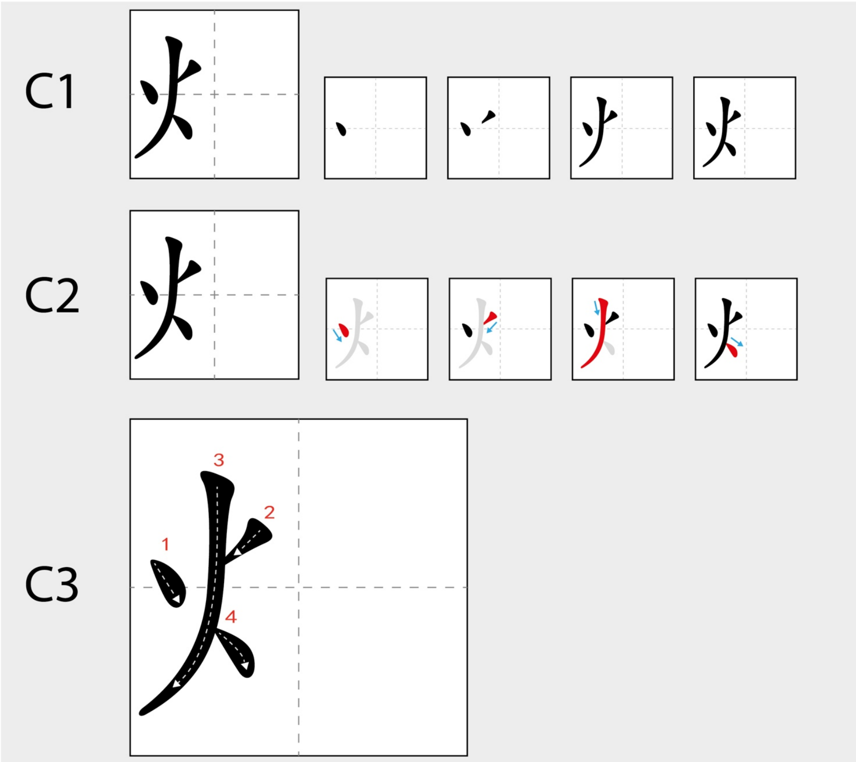


Figure 6-2. The developed samples C1, C2 and C3 of VIs for writing SRs.

6.3 Study 4: an experimental study on VIs for writing SRs

An experimental study was conducted to explore the effectiveness of the developed writing VIs (C1, C2 and C3). The effectiveness of writing SRs was measured by per cent accuracy and writing speed. The participants' choices after the writing task were also considered as an important aspect to measure the effectiveness. The null hypothesis (H_0) is that different instructions have no significant differences in terms of the effectiveness of writing SRs.

6.3.1 Methods

6.3.1.1 Participants

A total of 30 participants were recruited. The age range of the participants was from 19 to 54 with a mean age of 29. They were ab initio beginners of CCs and SRs, 15 were female and 15 were male. All the participants have studied or lived in the UK. They came from 11 different nationalities: 19 British, two Saudi Arabians, one Trinidadian, one Mexican, one Lithuanian, one Bangladeshi, one Russian, one Polish, one Cypriot, one Sri Lankan and one Indian.

6.3.1.2 Materials

Table 6-1 shows 15 SRs in samples C1, C2 and C3 in Study 4. The 15 SRs were divided into three groups. Each sample was applied with five SRs, from two strokes to six strokes. All the three groups of SRs have equal number of strokes with similar level of difficulty. To record the process of writing, the samples were tested on an 11-inch tablet. Therefore, an adapted page design (2,388 x 1,668-pixels) for presenting the VIs and writing places were produced.

Table 6-1. The 15 SRs used in samples C1, C2 and C3 in Study 4.

Sample	**SR1** 2 strokes	**SR2** 3 strokes	**SR3** 4 strokes	**SR4** 5 strokes	**SR5** 6 strokes
C1	讠	艹	火	钅	虫
C2	亻	忄	曰	衤	耳
C3	刂	犭	心	鸟	舟

Note: SR = Semantic Radical

Figure 6-3 shows the adapted pages of C1, C2 and C3 used in the writing test in Study 4, with SR Fire as an example. C1 and C2 both had a full presentation of the SR on the left, a stroke-by-stroke presentation of the SR on the right, and a practising place on the right under the stroke-by-stroke presentation. C3 had the all-in-one presentation on the left and the practising place on the right. All the stroke order and directions of the 15 SRs conformed the published standard writing of CCs (National Language Committee, 1997). All the 15-page VIs were listed in Appendix V.

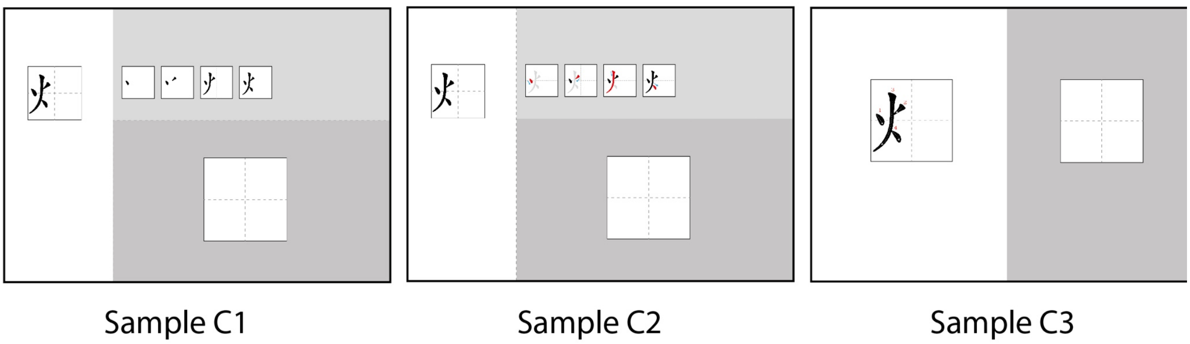


Figure 6-3. Samples C1, C2 and C3 of VIs for writing SRs in Study 4.

6.3.1.3 Procedure

First, participants were introduced the basic knowledge of CCs and SRs, which were the same as the experimental Study 3 (Section 5.4.1.2). Then, they were introduced the writing task and were given practice of using a stylus pen to write on a tablet. They were informed of what they could do if they would like to correct and rewrite SRs. The participants were not allowed to interrupt during the writing task for an unnecessary reason, unless they would like to withdraw the study, since the writing time was recorded. All the participants were told to write the SRs following the VIs rather than write as their wishes.

After the introduction part, all the participants did the writing task in Microsoft PowerPoint on an 11-inch tablet. The writing process and time spent (writing speed) were screen-recorded. The presenting of each slide had no time limit, as it needed the participants to swipe to the next slide when they finished the previous slide. They were not allowed to back to the previous slide to rewrite or correct their writing.

After they finished the writing task, they had a post-test survey, asking about which sample was the most effective VIs for the same number of strokes of SRs. Figure 6-4 shows the question sheets asked from two-stroke to six-stroke SRs in the post-test survey. The participants were all asked which one they think was the most explicit VI for them to write SRs. They could choose the one that they thought the most explicit VI, basing on their writing experience from the writing task. The order of the three options was different in the five questions, such as C1, C3, C2 or C3, C2, C1, which could avoid the participants from choosing the answer in a specific position unconsciously or without thinking carefully.

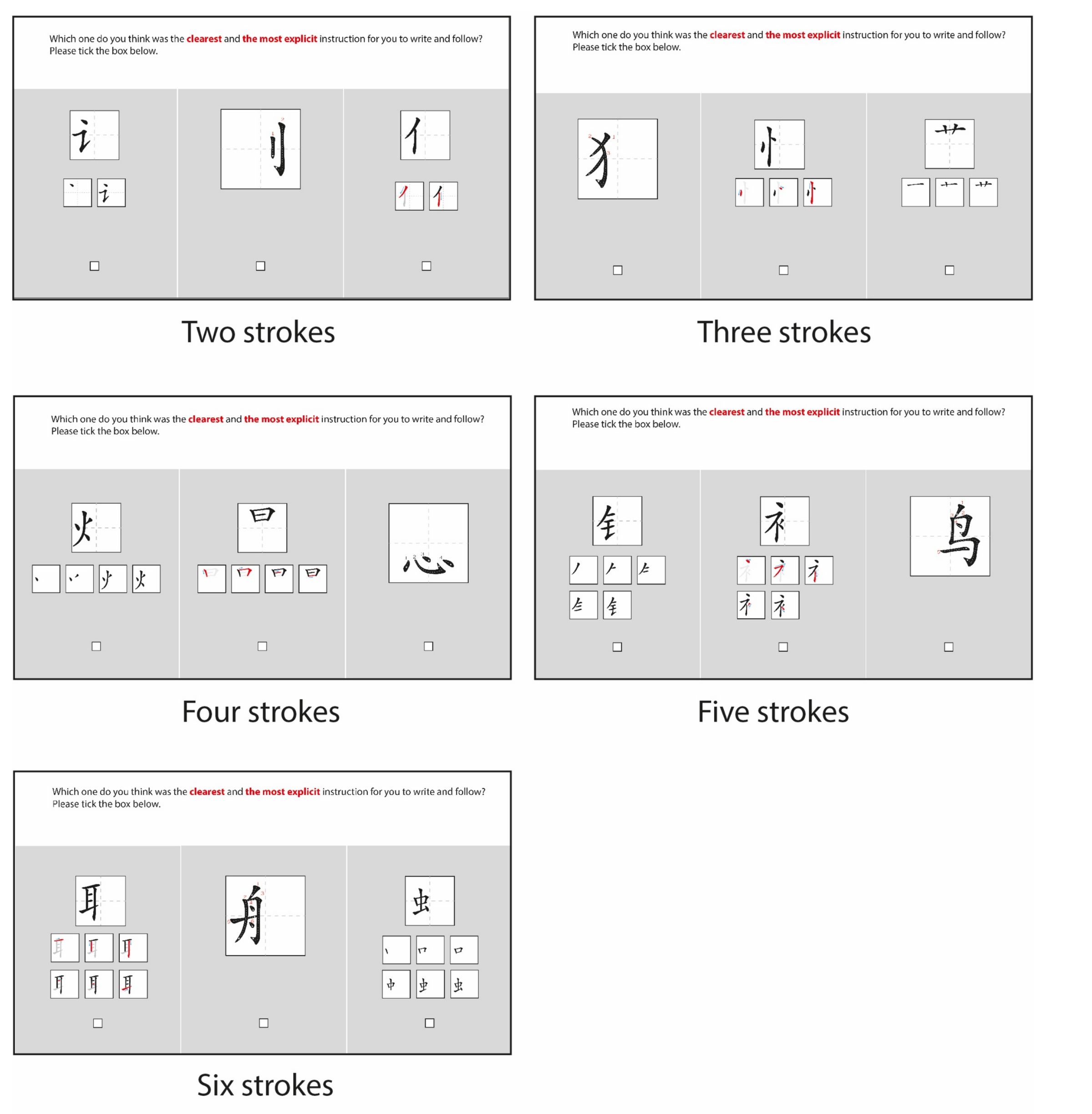


Figure 6-4. The question sheets in the post-test survey in Study 4.

6.3.2 Results

The results of Study 4 include the per cent accuracy of writing, error types, writing speed and post-test survey. Moreover, the participants had different writing habits with the VIs, which will be described after the results of the post-test survey.

Table 6-2 shows the average per cent accuracy, the results of SW test and WSR test of samples C1, C2 and C3. The accuracy of writing the 15 SRs with the three samples all showed a non-normal distribution, as the *p*-values of the SW normality test were smaller than 0.05. Hence, the WSR test was used to compare the differences between samples, which was the same as the statistical analyses in the study of VIs for Reading & Memorising SRs (Chapter 5). The results showed that the average per cent accuracy of C1 (77%) and C3 (79%) had no significant difference (p = 0.559 > 0.05). The average per cent accuracy of C2 (96%) was significantly higher than C1 (m = 77%, p_{C2-C1} = 0.000 <0.05) and C3 (79%, p_{C3-C2} = 0.001 <0.05). The results rejected the null hypothesis.

Table 6-2. The average per cent accuracy and the results of the SW test and WSR test of C1, C2 and C3 in Study 4.

Sample	**Average per cent accuracy**	**SD**	**SW Test**	**Compare Samples** (WSR Test)	
C1	77%	20%	p = 0.001	C1-C3	P_{C1-C3} = 0.559
C2	96%	10%	p = 0.000	C2-C1	p_{C2-C1} = 0.000
C3	79%	21%	p = 0.000	C3-C2	p_{C3-C2} = 0.001

Note: SD = Standard Deviation; SW = Shapiro-Wilk (SW) test

Table 6-3 shows the average accuracy of each SR of the 30 participants of C1, C2 and C3, which indicates some trends. While the number of strokes increases from SR1 to SR5, the visual complexity increases from SR1 to SR5. The per cent accuracy of SR4 (67%) and SR5 (67%) in C3 showed a sharp drop, while the accuracy of SR1 (100%), SR2 (80%) and SR3 (83%) were high. The accuracy of C1 and C2 did not show the sharp drop trend.

Table 6-3. The average per cent accuracy for specific SRs of C1, C2 and C3 in Study 4.

Sample	**SR1**	**SR2**	**SR3**	**SR4**	**SR5**
C1	90%	80%	67%	70%	77%
C2	100%	90%	93%	97%	100%
C3	100%	80%	83%	67%	67%

Note: SR = Semantic Radical

Three error types were found in the test: wrong stroke order (Error Type 1), wrong stroke directions (Error Type 2) and missing strokes (Error Type 3). Table 6-4 shows the times of different error types occurred of the participants when writing with C1, C2 and C3. The data in the column SR1 to SR5 in Table 6-4 is the times of different types of error occurred. The column of Sum shows the total number of times that the type of error occurred. In C1, Error Type 2 was the most (26 times) often made mistake. Error Type 1 had been made nine times. In C2, Error Type 1 had been made three times, and Error Type 2 had been made three times. In C3, Error Type 1 was the most often made mistake (17 times) and Error Type 2 was the second (12 times). Error Type 3 had been made twice in C3, and it has not been made in C1 and C2.

Table 6-4. The times of different error types occurred of C1, C2 and C3 in Study 4.

Sample		**SR1**	**SR2**	**SR3**	**SR4**	**SR5**	**Sum**
C1	Error Type1	1	0	3	4	1	**9**
	Error Type2	2	6	7	5	6	**26**
	Error Type3	0	0	0	0	0	**0**
C2	Error Type1	0	2	0	1	0	**3**
	Error Type2	0	1	2	0	0	**3**
	Error Type3	0	0	0	0	0	**0**
C3	Error Type1	0	1	2	6	8	**17**
	Error Type2	0	4	3	3	2	**12**
	Error Type3	0	1	0	1	0	**2**

Note: Error Type 1 = wrong stroke order; Error Type 2 = wrong stroke directions; Error Type 3 = missing strokes; SR = Semantic Radical

Table 6-5 shows the results of the average writing speed of individual SRs and the average writing speed of an SR with each sample and the results of the WSR test for the comparison of samples C1, C2 and C3. The columns of SR1 to SR5 demonstrated the average writing speed for each SR and the column of Average speed showed the speed of writing an SR with each sample. The rows of SW test showed the *p*-values of the SW test, which indicated the data distribution of each group of data. The row of WSR test showed the *p*-values of the WSR test, which showed the significance of comparisons between samples.

Table 6-5. The average writing speed of individual SRs and the average writing speed of an SR with each sample and the results of the WSR test for the comparison of samples C1, C2 and C3.

		SR1	**SR2**	**SR3**	**SR4**	**SR5**	**Average speed**(s)
C1	Speed (s)	6	4	7	9	12	8
	SD(s)	4	2	3	3	5	4
	SW test	$p = 0.000$	$p = 0.119$	$p = 0.000$	$p = 0.155$	$p = 0.055$	$p = 0.000$
C2	Speed (s)	3	4	6	10	14	8
	SD(s)	2	2	4	5	6	6
	SW test	$p = 0.008$	$p = 0.030$	$p = 0.000$	$p = 0.019$	$p = 0.004$	$p = 0.000$
C3	Speed (s)	4	6	5	12	10	8
	SD(s)	3	2	1	4	5	5
	SW test	$p = 0.000$	$p = 0.003$	$p = 0.037$	$p = 0.039$	$p = 0.014$	$p = 0.000$
WSR test	C1-C2	$p = 0.000$	$p = 0.123$	$p = 0.338$	$p = 0.451$	$p = 0.044$	$p_{C1-C2} = 0.410$
	C1-C3	$p = 0.047$	$p = 0.001$	$p = 0.000$	$p = 0.001$	$p = 0.050$	$p_{C1-C3} = 0.924$
	C3-C2	$p = 0.011$	$p = 0.024$	$p = 0.056$	$p = 0.005$	$p = 0.000$	$p_{C3-C2} = 0.719$

Note: SD = Standard Deviation; SR = Semantic Radical; SW test = Shapiro-Wilk; WSR test = Wilcoxon Signed-Rank test

The results showed that the writing speed of C1 (8s), C2 (8s) and C3 (8s) had no significant differences, as all the *p*-values were larger than 0.05 ($p_{C1-C2} = 0.410$, $p_{C1-C3} = 0.924$, $p_{C3-C2} = 0.719$). To be specific, the results of the writing speed of individual SRs with different samples showed that some were one or two seconds longer than others; some were significant; and some were not significant. The longer or shorter writing time of different SRs showed no obvious patterns. Therefore, the results of writing time of the three samples showed no significant differences.

Table 6-6 shows the results of the post-test survey. It shows the participants' choices of the most effective sample among C1, C2 and C3, basing on their writing experiences. It also shows the percentage of the 30 participants who chose the sample as the most effective VIs for writing SRs. The column of Choice for C1/C2/C3 shows the percentage of the final choice of the three samples, while the columns of SR1 to SR5 showed the percentage of the participants' choices for individual SRs. In terms of the final choice, 72% of the participants chose C2 as the most effective VIs for writing SRs. C3 was chosen by 17% of the participants, while C1 was chosen by 9% of the participants. To be specific, the percentage of the participants who chose C1 as the most effective VI for individual SRs was consistently below 15%, and none of the participants chose C1 for SR1. More than 60% of the participants chose C2 for all the five SRs. SR1 and SR5 were chosen for C2 by more than 80% of the participants. There were at least 20% of the participants chose C3 for writing SR1, SR2 and SR3. However, it showed a decrease in SR4 and SR5, which had more strokes for writing.

Table 6-6. The results of the post-test survey.

	SR1	SR2	SR3	SR4	SR5	Choice for C1/C2/C3
C1	0	10%	10%	13%	10%	9%
C2	80%	63%	63%	70%	83%	72%
C3	20%	23%	27%	10%	7%	17%

Note: SR = Semantic Radical

It was noticed that the participants had two different ways to write SRs with the VIs. Twenty-one participants read the VI and wrote the first stroke. Then they reread the VI and wrote the second stroke. This process was repeated until the participants finished writing the SR. Nine participants read the whole VIs first, and then practised the whole process in air. Finally, they wrote the SR in once without looking the VI again. Moreover, it was found that C3 was not easy to use for left-handed participants, as they would easily cover the VI (on the left of the page) when they wrote by using left hands. Three participants were left-handed users in Study 4.

6.4 Discussion

The aim of Study 4 was to explore the effectiveness of VIs for writing SRs. The main finding was that the stroke-by-stroke VI with colour hints and arrows (C2) had significantly higher accuracy than that without colour hints and arrows (C1) and the all-in-one VI with numbers and arrows (C3). All the three samples showed no significant differences regarding writing speed. The results of the post-test survey also showed that the majority (72%) of the participants chose C2 as the most explicit VI for writing SRs among C1, C2 and C3.

Comparing C1 and C2 (stroke-by-stroke VIs), C2 was presented with colour hints and arrows. The colour hints in C2 were not explained to the participants; therefore, the results proved that the colour hints in C3 was easy to understand. The effectiveness of colour hints was in accordance with the findings in the literature review. First, chromatic colour draws more attention than achromatic colour (Olurinola and Tayo, 2015; Pettersson, 2015a; 2019). Moreover, colour could boost clarity and distinction, and different colours could show different levels of information (Mijksenaar, 1997; Pettersson, 2015a; 2019). These explained that the strokes were designed in red, black and grey in C2 were easy to be understood by the participants. The colour not only showed the order but also separated different strokes. When many different shapes of strokes were joint together and showed in the same colour, it was not easy to pick one out as a whole stroke, especially for beginners.

The use of arrows in C2 significantly reduced the number of wrong stroke directions (Error Type 2) for writing, especially compared with C1 (no arrows). Arrows indicate the directions and suggest movements as a powerful visual element (Horton, 1993; Horn, 1998; Pettersson, 2013a). The effect of arrows in C3 also showed a decrease of Error Type 2. However, the number of Error Type 2 in C2 (3 times) was greatly smaller than the number in C3 (12 times). The reason might be that C3 had too many arrows on one page, which was not suggested (Barker and Fraser, 2004; Amare and Manning, 2016). Moreover, the arrows were shown inside strokes in C3, which were not obvious to see. If the arrows were placed around strokes rather than inside strokes, it would cause more visual complexity, as many arrows would be displayed in one page. Therefore, the arrows worked better in the stroke-by-stroke VI rather than in the all-in-one VI. The use of arrows for instruction needed to be tested, since different variables of arrows and different applications influenced the effect of arrows. A considered application of an arrow could make the most use of it, while an inappropriate application might reduce its effectiveness.

The stroke order was shown by numbers around strokes in C3 (all-in-one VI), while the stroke order was displayed step by step in C1 and C2 (stroke-by-stroke VIs). C2 had extra colour hints to highlight the stroke order. Error Type 1 (wrong stroke order) was made nine times in C1, three times in C2 and 17 times in C3 by the participants. It showed that the stroke-by-stroke VIs (C1 and C2) worked better than the all-in-one VI (C3) in terms of showing stroke order. Comparing C1 and C2, the results showed that the participants made fewer Error Type 1 in C2 than C1. Therefore, the colour hints in C2 showed a positive effect in reducing Error Type 1.

Error Type 3 (missing strokes) only happened twice in C3, while it did not happen in C1 and C2. The reason might be that the all-in-one VI (C3) was hard to follow. Therefore, it was easy to miss strokes. It was another drawback of the all-in-one VI.

The results of C3 in the writing task showed a trend that the per cent accuracy of SRs with five to six strokes decreased to 67%, compared with SRs with one to three strokes (above 80%). The results of the post-test survey also showed a sharp decrease for SRs with five and six strokes (SR4: 10%, SR5:7&), compared with SRs with SRs with two to three strokes (SR1:20%, SR2:23%, SR3: 27%). Thus, the effect of C3 (all-in-one VI) worked better for SRs with fewer strokes than SRs with more strokes.

The all-in-one VI had inevitably visual complexity to a certain extent. Instructing writing SRs with the all-in-one VIs for fewer-stroke SRs (less than three strokes) might be acceptable, but it is too complicated for instructing SRs with more than three strokes. Therefore, to further explore the effectiveness of VIs for writing SRs, the all-in-one VI would not be considered in the following experimental study.

Although the all-in-one VI (C3) would not be further tested in the following experimental study, the findings of this study also suggested that VIs had similar layout with C3 should avoid a left-and-right layout, which may cause ineffectiveness for left-handed or right-handed users. Accordingly, an up-and-down layout for VIs and writing places was both accessible to right-handed and left-handed users.

Most participants (21 of 30) read VIs and wrote a stroke, then reread VIs until they finished. The other participants read VIs for a longer time, practised in air, then wrote SRs without looking at VIs. It can be explained as different reading and writing habits, but it also can be understood as that beginners were not familiar with the Chinese writing system. Skipping repeatedly from reading VIs and writing practice needed more explicit VIs than doing it in once, as it might be easier to make mistakes. Therefore, it is essential to produce an explicit VI for writing SRs by beginners.

6.5 Conclusions

Study 4 examined the effectiveness of three VIs for writing SRs (C1: simple stroke-by-stroke VI; C2: stroke-by-stroke VI with colour hints and arrows; C3: all-in-one VI with numbers and arrows). Study 4 tested the effectiveness of VIs for writing practice rather than memorising the rules of writing.

The results of Study 4 showed that C2 had significantly higher accuracy than C1 and C3. All the three VIs showed no significant differences in the writing speed. The results of the post-test survey also showed that 72% of the participants chose C2 as the most explicit VIs for writing SRs among the three VIs.

The results showed that the application of arrows in the stroke-by-stroke VI significantly reduced the error numbers of wrong stroke direction in writing practice, while the use of arrows in the all-in-one VI slightly reduced the error numbers of wrong stroke direction. The results indicated that the all-in-one VI was not suggested, especially for SRs with more than three-stroke numbers. Applying numbers to show stroke order and arrows to show stroke directions in the all-in-one VI are inevitable to increase the visual complexity and therefore reduce the effectiveness of VIs. The error of missing strokes only occurred twice during the whole study when the participants wrote SRs with the all-in-one VI. Thus, the all-in-one VI was not suggested.

To further test the effectiveness of colour hints and arrows for memorising writing rules of individual SRs, the stroke-by-stroke VIs with colour hints and arrows were further explored in the following Study 5 (Section 7.3).

7 Study of VIs for Reading & Memorising and writing SRs

7.1 Introduction

The study of VIs for Reading & Memorising and writing SRs aimed to investigate their effectiveness together. This study was based on the results of the study of VIs for Reading & Memorising SRs (Chapter 5) and the results of the study of VIs for writing SRs (Chapter 6).

The study of VIs for Reading & Memorising SRs (Chapter 5) resulted in that the integrated illustrations and the colour-coded integrated illustrations both significantly increased the effectiveness of memorising SRs by non-specialist beginners. The colour-coded integrated illustrations showed significantly higher accuracy than integrated illustrations for memorising the positions of SRs in IT. This study further investigated the difference between those two different VIs with an expanded sample size of SRs.

The study of VIs for writing SRs (Chapter 6) found that the stroke-by-stroke VI with colour hints and arrows significantly increased the effectiveness of writing SRs by non-specialist beginners, in terms of writing practice. This study further investigated the effectiveness of colour hints and arrows in the stroke-by-stroke VI separately. Moreover, this study explored the effectiveness of VIs for memorising the stroke order and directions for writing SRs with an expanded sample size of SRs.

The materials in Study 3 (Appendix IV) and Study 4 (Appendix V) were the bases of materials in Study 5. The findings of Study 3 and Study 4 also showed some points for design improvement. In this study, firstly, the VIs were improved according to the suggestions in Study 3 and Study 4. The improved VIs were used as materials in Study 5.

Study 5 examined the effectiveness of the VIs in terms of per cent accuracy and answering speed in IT and DT.

7.2 Design improvement: VIs for Reading & Memorising and writing SRs

The design improvement aimed to refine the VIs in Study 3 and Study 4. Moreover, it aimed to find an appropriate way to make the VIs for Reading & Memorising SRs and the VIs for writing SRs show their effects in the experimental study.

Study 3 (Section 5.4) found samples B3 and B5 were the effective VIs for Reading & Memorising SRs. Study 4 (Section 6.3) found sample C2 was the effective VIs for writing SRs. To further examine the effectiveness of the VIs, the simple VIs (i.e., B1 and C1) and the effective VIs (i.e., B3, B5 and C2) were the basic VIs in the design improvement. The improved VIs were D1, D2 and D3, which would be used as materials in Study 5. Figure 7-1 shows the design improvement of VIs for Reading & Memorising SRs from sample B to D (page one), with SR Fire as an example. Figure 7-2 shows the design improvement of VIs for writing SRs from sample C to D (page two), with SR Fire as an example. The first page in sample D was VIs for Reading & Memorising SRs and the second page in sample D was VIs for writing SRs.

In regard to VIs for Reading & Memorising SRs, the participants in Study 3 indicated that the brown colour for the bottom position in the colour coding was not very obvious to see when it was overlapped with black SRs. Therefore, to make the bottom colour in the colour coding obvious to see, the brown colour was replaced by a bright red colour (Figure 7-1). Moreover, participants in Study 3 pointed out SR Walk (辶) and SR Shelter (厂) informed their positions by their own shapes. Therefore, SRs with left-and-bottom positions and left-and-top positions would not be tested in Study 5. The corresponding squares (and) with colour coding were also removed in sample D. To place more emphasis on SRs in VIs, the big size CCs in sample B was removed in sample D. The layout was changed from the left-and-right layout in sample B to the up-and-bottom layout in sample D accordingly. To simplify the VIs, the black squares in B1 and B3 were also removed in D1 and D2. It was because when the big size CC was removed, the black squares looked unreasonable and might split learners’ attention. Only the colour coded squares in B5 were retained in D3 while the colour was changed.

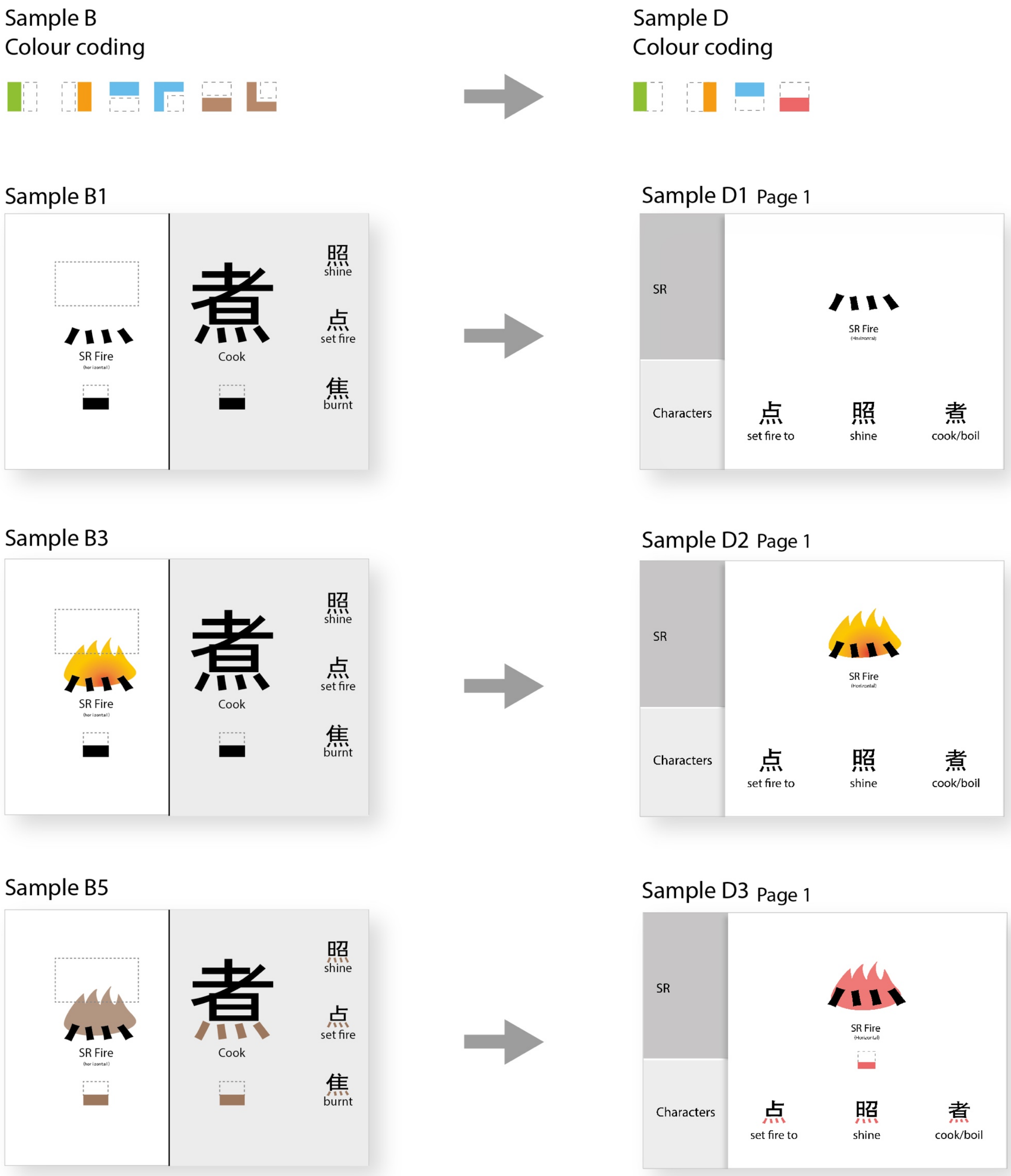


Figure 7-1. The design improvement of VIs for Reading & Memorising SRs from sample B to D (page 1).

For VIs for writing SRs, the layout in sample D (page two) was changed to keep consistent with page one. Moreover, a grey hint of SR was added in the two big squares in sample D to assist the participants in practising writing. The two practising places (two big squares) aimed to allow the participants to have more time to practise and prepare for the following memory test. The enlarged

VI in C2 was shown in Figure 7-2. Samples C1 and D1 were the simple VIs. Sample C2 had both colour hints and arrows. To investigate the effectiveness of colour hints and arrows separately, both samples D2 and D3 used colour hints, while D3 used arrows additionally.

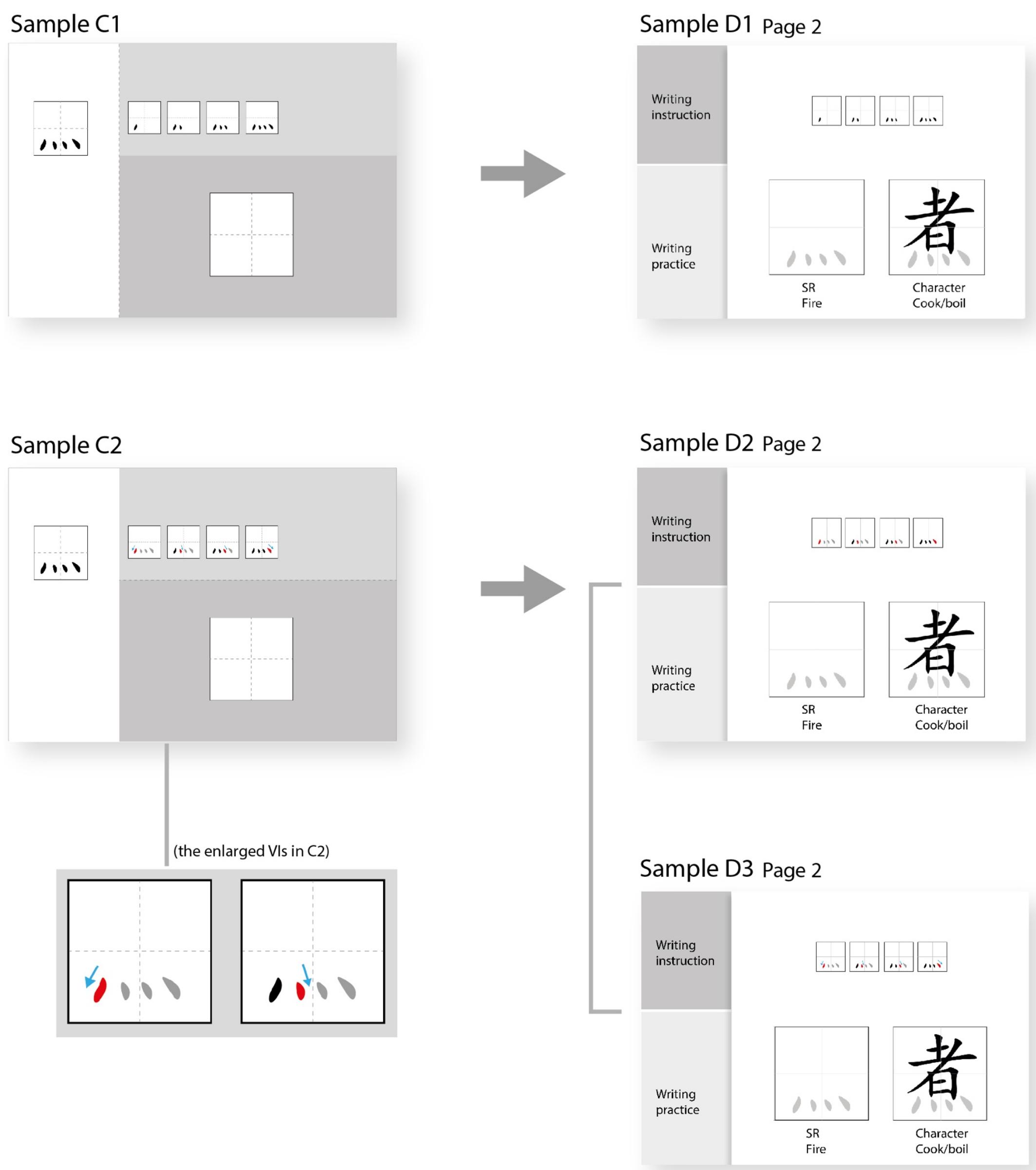


Figure 7-2. The design improvement of VIs for writing SRs from sample C to D (page 2).

7.3 Study 5: an experimental study on VIs for Reading & Memorising and writing SRs

Study 5 aimed to examine the effect of VIs for Reading & Memorising SRs and writing SRs together in IT and DT. The null hypothesis (H_0) is that the VIs do not have effect on memorising SRs after reading and writing with VIs.

Study 5 had five objectives:

1) To further examine the effectiveness of integrated illustrations for Reading & Memorising SRs.
2) To compare the effect of the integrated illustrations and the colour-coded integrated illustrations for Reading & Memorising SRs.
3) To compare the effect of VIs for Reading & Memorising SRs in IT and DT.
4) To explore the effect on memorising writing rules of SRs after writing with colour hints in stroke-by-stroke VIs.
5) To explore the effect on memorising writing rules of SRs after writing with arrows in stroke-by-stroke VIs.

7.3.1 Methods

7.3.1.1 Participants

A total of 30 participants were recruited. The age range of the participants was from 19 to 32, with a mean age of 21. They were ab initio beginners regarding CCs and SRs. Half of them were female and another half were male. All the participants lived or studied in the UK. They were from 11 different nationalities: 16 British, four Indians, two Pakistanis, one Saudi Arabian, one French, one Northern Irish, one Nigerian, one Omani, one Latvian, one Sri Lankan and one Polish. They were named from S5P1 to S5P30.

7.3.1.2 Materials

The materials used in Study 5 were samples D1, D2 and D3, which were improved from samples B and C (Section 7.2). Table 7-1 shows 21 SRs into three groups (seven SRs each group) with their number of strokes. Each group of SRs was applied in all the three samples (D1, D2 and D3). Each SR had two pages of VIs, including the first page of VIs for Reading & Memorising and the second page of VIs for writing practice. A total of 126 pages of VIs were designed and listed in Appendix VI. Each participant was only tested with 21 SRs (42 pages of VIs). The descriptions of the three samples are listed below:

- **Sample D1**: simple VIs for Reading & Memorising and writing SRs.
- **Sample D2**: VIs with integrated illustrations for Reading & Memorising SRs and VIs with colour hints for writing SRs.
- **Sample D3**: VIs with colour-coded integrated illustrations for Reading & Memorising SRs and VIs with colour hints and arrows for writing SRs.

Table 7-1. The three groups of the 21 SRs used in Study 5.

	SR1	**SR2**	**SR3**	**SR4**	**SR5**	**SR6**	**SR7**
Group 1	阝	犭	宀	牛	日	禾	米
Strokes	2	3	3	4	4	5	6
Group 2	刂	巾	忄	心	火	穴	虫
Strokes	2	3	3	4	4	5	6
Group 3	氵	艹	彳	灬	木	鸟	⺮
Strokes	2	3	3	4	4	5	6

Note: SR = Semantic Radical

Apart from VIs for Reading & Memorising and writing SRs, all the participants were shown the basic concepts, introducing the knowledge that they needed to know before testing, including the structures of CCs, SRs and strokes (writing rules). Figure 7-3 shows the four pages of the introduction materials.

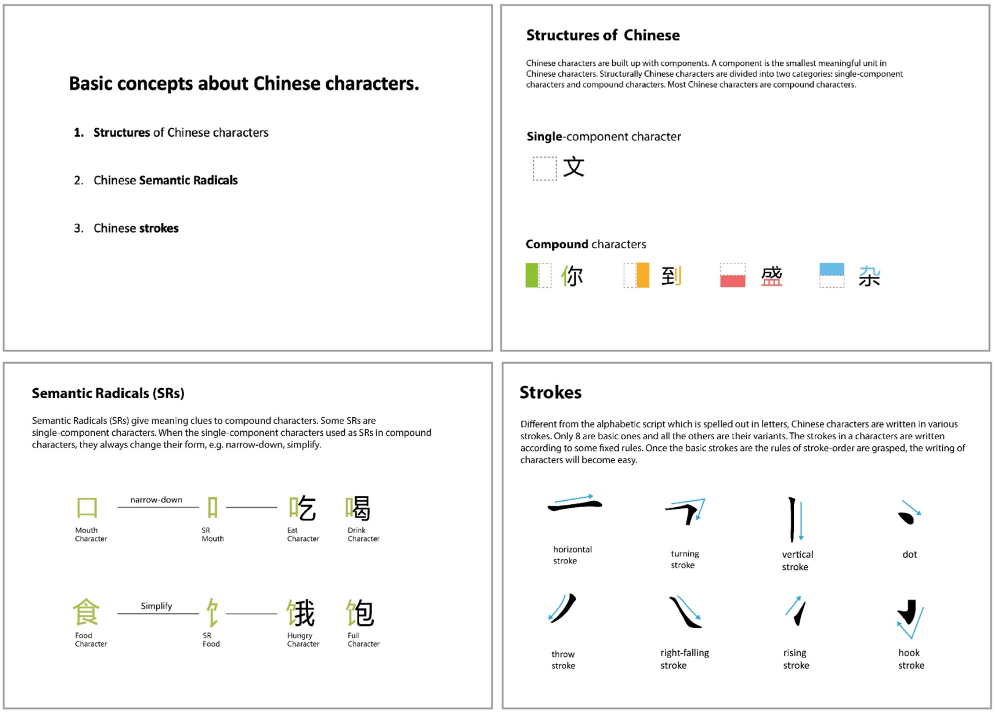


Figure 7-3. The introduction material of the basic concepts of CCs.

7.3.1.3 Procedure

The whole study was conducted on an 11-inch tablet with a stylus pen. All the materials were displayed in Microsoft PowerPoint on the device. All participants used the same devices.

First, all the participants were shown the introduction materials (Figure 7-3). Then, they were briefed the three samples of the learning materials and tried an example to adapt writing with a stylus pen. The 42-page VIs had 21 pages for Reading & Memorising SRs and 21 pages for writing SRs. For learning the 21 SRs, the first shown page was the VI for Reading & Memorising and the second shown page was the VI for writing. All the first pages for Reading & Memorising SRs lasted 20 seconds. The time length was set the same as Study 3. For writing the 21 SRs (the second page of VIs), the participants had 15 seconds to write two-stroke to three-stroke SRs, 18 seconds to write four-stroke SRs and 20 seconds to write five-stroke to six-stroke SRs, as SRs with more strokes needed longer time to write. The time setting was based on the results of Study 4, and the feasibility of the time testing had been verified before the experiment with two participants (not from the 30 participants). All the 21 SRs could be practised twice in the given two squares. The time setting was achieved by using Microsoft PowerPoint, which could set different time length of lasting for different slides.

Next, they were asked to learn the three groups of SRs from Group 1, Group 2 to Group 3 with different samples (D1, D2 and D3). For clarity, Figure 7-4 shows the visualisation of grouping and combinations of samples D1, D2 and D2, and the three groups of SRs tested by the 30 participants. In Figure 7-4, the three colours represent three different samples of VIs. Orange is D1, green is D2 and blue is D3. Three shapes represent three groups of SRs. The square represents G1 (Group 1), the triangle represents G2 (Group 2) and the round represents G3 (Group 3). All the participants were asked to learn SRs from G1, G2 to G3 (seven SRs per group). A total of 63 applications of the three samples with the 21 SRs. The participants only tested 21 of the 63 applications. In other words, the participants only tested one samples (D1, D2 or D3) for G1, one sample for G2 and one sample for G3. The three samples have to be different from each other. For example, participant S5P6 learnt SRs from G1, G2 to G3 with VIs D2, D1 to D3. The order of G1, G2 to G3 was fixed to all participants, but the order of samples was shifting. There were only six different combinations of the three samples, as they are shown in the column of combinations in Figure 7-4. For the 30 participants, every five participants learnt the 21 SRs with one of the combinations. For example, participants S5P11 to S5P15 learnt the SRs from G1D3, G2D2 to G3D1. This strategy aimed to minimise the variances of SRs between groups.

Note: G1 = Group 1; G2 = Group 2; G3 = Group 3; SR = Semantic Radical

Figure 7-4. The visualisation of grouping and combinations of D1, D2 and D2, and the three groups of SRs.

After the learning task, they all had a memory test, including asking MRQs, PRQs and RRQs, and writing the 21 SRs. In Study 3, the memory test was conducted online through Google Forms. In Study 4, the writing test was conducted on a tablet with a stylus pen. To simplify the complexity of the testing process in Study 5, the test was conducted as a simulated paper-and-pencil test, which was achieved by using a tablet and a stylus pen.

Figure 7-5 shows the layout explanation of the memory test sheets with the sheets for SR Heart as an example. The test sheets were divided into two parts. The first part asked MRQs, PRQs and the writing of the 21 SRs. The second part asked PRQs. The participants must finish the first part of the memory test. Then, they started to do the second part. This strategy aimed to ensure that the PRQ and the RRQ of the identical SR were not next to each other in the memory test. Thus, the participants would not be shown possible answers in the options of the PRQ or the RRQ of the same SR.

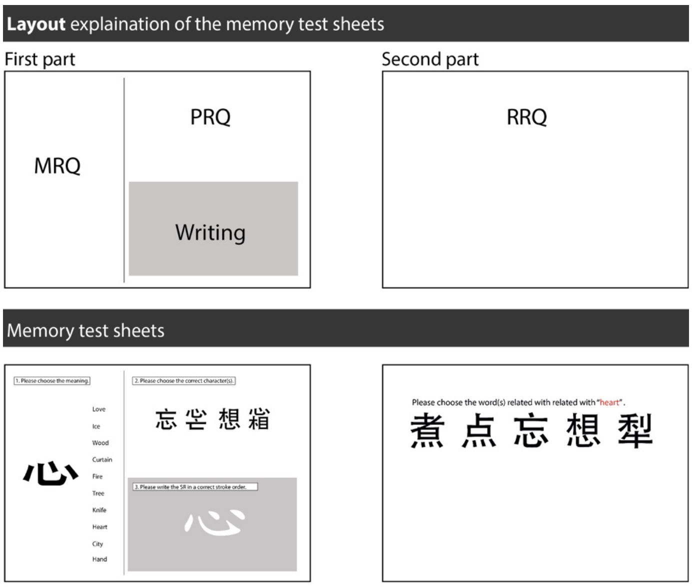
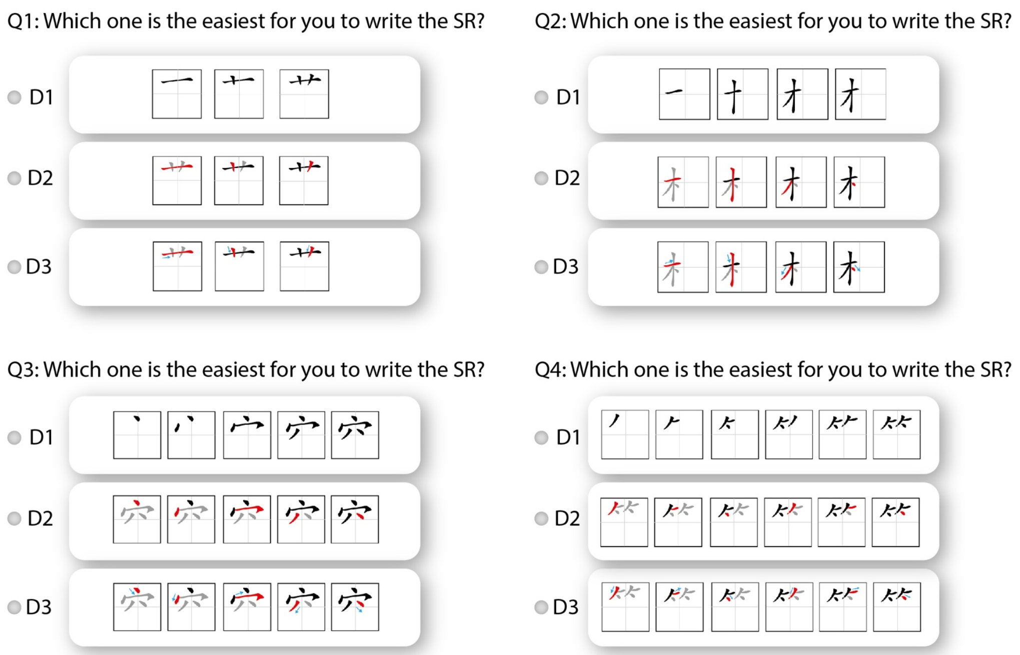


Figure 7-5. Layout explanation of the memory test sheets, and an example of the memory test sheets (example: SR Heart).

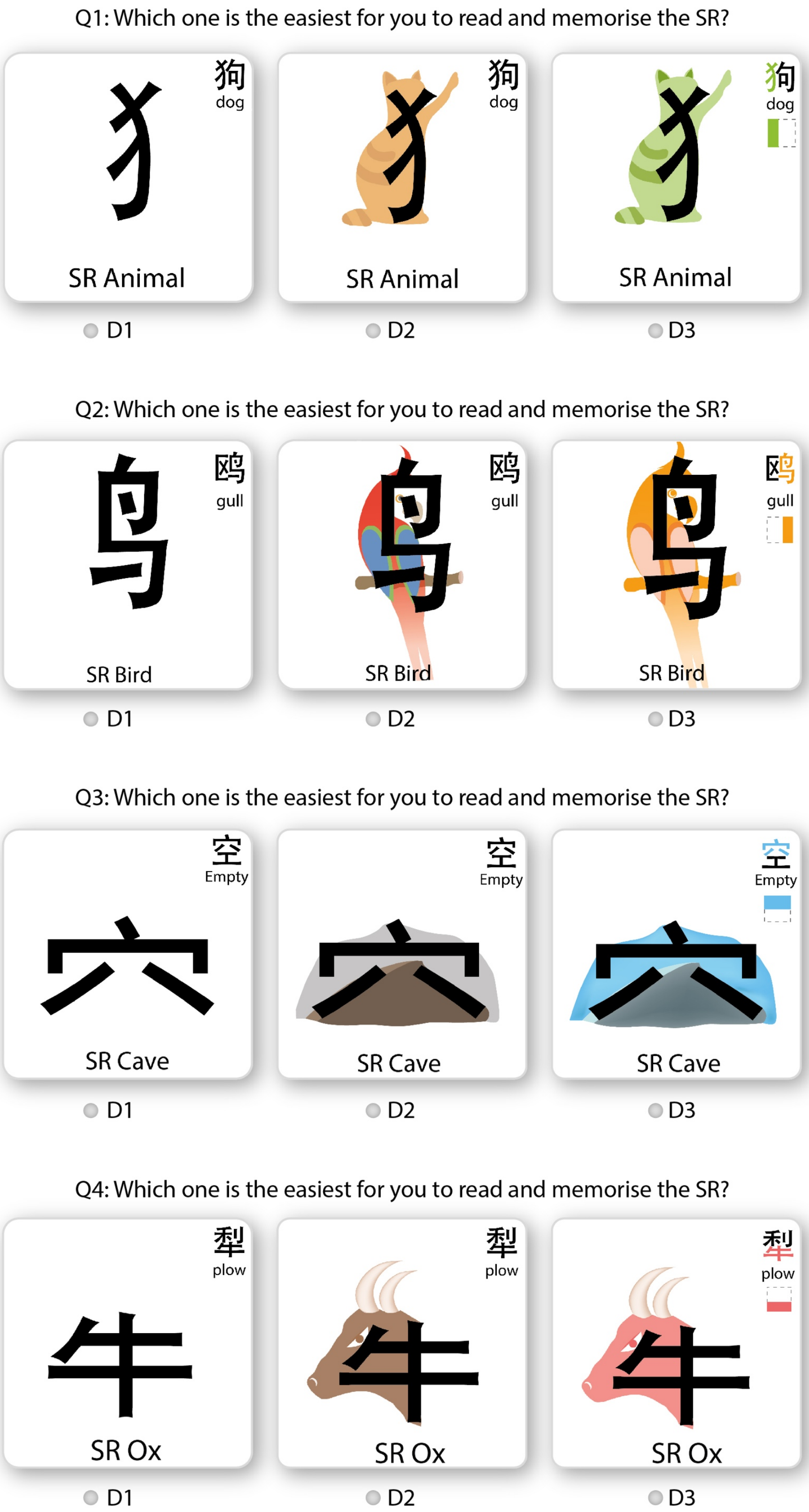
Figure 7-5 also shows the test sheets with the SR Heart as an example. While doing the test, the participants only needed to circle or tick the answer they chose and write the SR on the provided white SR. For answering the MRQs, 10 options were provided for each MRQ, and only one option was the correct answer. For answering PRQs, the participants were shown four CCs, including real CCs and fake CCs. The fake CCs have the SRs in wrong position. Four options were provided for each PRQ. One or two options were correct answer(s). For answering the RRQs, five options were provided for each RRQ. One or two options were correct answer(s). The writing test aimed to examine whether the participants write SRs in accurate stroke order and stroke directions. The test did not have a time limit for each page. When the participants finished a slide, they needed to swipe it to the next slide. The whole process was screen recorded.

The whole process cost about 30 to 40 minutes, depending on different participants. After seven days, all the participants were asked to do the memory test (i.e., DT) again in the same room, which cost about 10 minutes. After they finished the DT, they all had a post-test survey of the VIs. For the post-test survey, all the participants were asked to choose one from the three samples as the easiest VIs for them to learn SRs. This question was repeated four times (Q1, Q2, Q3, Q4) with different visual examples from the materials they had tested. The VIs for writing SRs (Figure 7-6) and VIs for Reading & Memorising SRs (Figure 7-7) were asked separately. For every five participants, the visual examples were changed. All the visual examples were selected from the samples D1, D2 and D3 (Appendix VI) in Study 5. Last, they were asked to scale how they agree with the given functions of the integrated illustrations and the colour coding.



Note: SR = Semantic Radical; Q = Question

Figure 7-6. An example of the four questions about the VIs for writing SRs in the post-test survey.



Note: SR = Semantic Radical; Q = Question

Figure 7-7. An example of the four question about the VIs for Reading & Memorising SRs in the post-test survey.

7.3.2 Results

The results of Study 5 include the results of the memory test (per cent accuracy, error types of writing and answering speed), the results of the post-test survey and the participants' spontaneous comments.

The results of the memory test and the post-test survey are mainly quantitative data while the comments are qualitative data. Regarding the quantitative data, both inferential statistics and descriptive statistics were used to analyse. For the results of the memory test, statistical tests were used to compare the difference between the three samples. The distribution of the data was tested by SW test, and the *p*-values of the SW test were listed in each table of the results. Some of the data was normal distribution ($p > 0.05$) and some others was non-normal distribution ($p < 0.05$). For comparing, the dependent *t*-test (parametric test) was used for the data that was normal distribution. The WSR test (non-parametric) was used for the data that was non-normal distribution. The choices of the dependent *t*-test or the WSR test will not be repeated. For describing the data below, if the *p*-values of the WSR test and the *t*-test were listed in one table, they were shown as p_w for WSR test and p_t for the *t*-test. If the whole table only shows *p*-values of WSR test or *t*-test, they were shown as *p*.

7.3.2.1 The results of the memory test in Study 5

Table 7-2 shows the average per cent accuracy for answering the MRQs, PRQs and RRQs, *p*-values of the SW test and WSR test in the IT and DT.

The accuracy of the MRQs in the IT showed that D2 (70%) and D3 (74%) were all significantly higher than D1 (50%, $p_{D1\text{-}D2} = 0.000 < 0.01$, $p_{D1\text{-}D3} = 0.000 < 0.01$). The accuracy of D2 and D3 did not show a significant difference ($p_{D2\text{-}D3} = 0.121 > 0.05$). Similarly, the accuracy of the MRQs in the DT showed that D2 (67%, $p_{D1\text{-}D2} = 0.000 < 0.01$) and D3 (72%, $p_{D1\text{-}D3} = 0.000 < 0.01$) were all significantly higher than D1 (48%). The accuracy of D2 and D3 did not show a significant difference ($p_{D2\text{-}D3} = 0.127 > 0.05$). The results reject the null hypothesis.

The accuracy of the PRQs in the IT showed that D3 (83%) was significantly higher than D1 (59%, $p_{D3\text{-}D1} = 0.000 < 0.01$) and D2 (64%, $p_{D2\text{-}D3} = 0.000 < 0.01$). The accuracy of D1 and D2 did not show a significant difference ($p_{D1\text{-}D2} = 0.114 > 0.05$). Similarly, the results of the accuracy in the DT showed that D3 (80%) was significantly higher than D2 (66%, $p_{D2\text{-}D3} = 0.002 < 0.01$) and D1 (61%, $p_{D3\text{-}D1} = 0.000 < 0.01$). The accuracy of D1 and D2 had no significant difference ($p_{D1\text{-}D2} = 0.280 > 0.05$).

Table 7-2. The results of average per cent accuracy for answering the MRQs, PRQs and RRQs and the results of the SW test and WSR test of D1, D2 and D3.

Questions	**Test**	**Sample**	**Accuracy**	**SD**	**SW Test**	**Compare Samples** (WSR test)
MRQs	IT	D1	50%	30%	*p* = 0.108	p_{D1-D2} =0.000
		D2	70%	23%	*p* =0.003	p_{D2-D3} =0.121
		D3	74%	24%	*p* =0.002	p_{D3-D1} =0.000
	DT	D1	48%	28%	*p* = 0.134	p_{D1-D2} =0.000
		D2	67%	21%	*p* =0.045	p_{D2-D3} =0.127
		D3	72%	20%	*p* =0.004	p_{D3-D1} =0.000
PRQs	IT	D1	59%	26%	*p* =0.096	p_{D1-D2} =0.114
		D2	64%	19%	*p* =0.010	p_{D2-D3} =0.000
		D3	83%	17%	*p* =0.000	p_{D3-D1} =0.000
	DT	D1	61%	24%	*p* =0.149	p_{D1-D2} =0.280
		D2	66%	18%	*p* =0.008	p_{D2-D3} =0.002
		D3	80%	18%	*p* =0.003	p_{D3-D1} =0.000
RRQs	IT	D1	66%	20%	*p* =0.111	p_{D1-D2} = 0.009
		D2	75%	24%	*p* = 0.001	p_{D2-D3} = 0.065
		D3	84%	20%	*p* = 0.000	p_{D3-D1} = 0.001
	DT	D1	66%	20%	*p* = 0.098	p_{D1-D2} = 0.016
		D2	74%	18%	*p* = 0.010	p_{D2-D3} = 0.080
		D3	82%	20%	*p* = 0.000	p_{D3-D1} = 0.000

Note: DT = Delayed Test; IT = Immediate Test; SD = Standard Deviation; SW test = Shapiro-Wilk; MRQ = Meaning Recall Question; PRQ = Position Recall Question; RRQ = Radical Recall Question; WSR test = Wilcoxon Signed-Rank test

The accuracy of the RRQs in the IT showed that D2 (75%) and D3 (84%) were all significantly higher than D1 (66%, $p_{D1-D2} = 0.009 < 0.05$, $p_{D3-D1} = 0.001 < 0.05$). The accuracy of D2 and D3 did not show a significant difference ($p_{D2-D3} = 0.065 > 0.05$). Similarly, the accuracy of the RRQs in the DT showed that D2 (74%) and D3 (82%) were all significantly higher than D1 (66%, $p_{D1-D2} = 0.016 < 0.05$, $p_{D3-D1} = 0.000 < 0.01$). The accuracy of D2 and D3 did not show a significant difference ($p_{D2-D3} = 0.08 > 0.05$).

Table 7-3 shows the results of the WSR test or *t*-test for comparing the average per cent accuracy in the IT and DT and the results of Pearson's r to show the correlations between the IT and DT of the MRQs, PRQs and RRQs. The results showed that the accuracy of the MRQs, PRQs and RRQs in the IT and DT had no significant difference, as all the *p*-values were larger than 0.05 (refers to the *p*-values of the WSR test or the *t*-test in Table 7-3). All the accuracy in the IT and DT had a significantly positive correlation ($0 < r < 1$, $p < 0.01$, refers to Table 7-3).

Table 7-3. The results of WSR test or *t*-test for comparing the average per cent accuracy of IT and DT and the results of Pearson's r to show the correlations between IT and DT for samples D1, D2 and D3 of MRQs, PRQs and RRQs.

Questions	Sample	Accuracy		Compare Samples IT-DT (WSR test/ *t*-test)		Correlations (Pearson's r)	
MRQs	D1	IT:	50%	D1	$p_t = 0.322$	$r_{D1} = 0.894$	$p_{D1} = 0.000$
		DT:	48%				
	D2	IT:	70%	D2	$p_w = 0.567$	$r_{D2} = 0.570$	$p_{D2} = 0.001$
		DT:	67%				
	D3	IT:	74%	D3	$p_w = 0.526$	$r_{D3} = 0.763$	$p_{D3} = 0.000$
		DT:	72%				
PRQs	D1	IT:	59%	D1	$p_t = 0.437$	$r_{D1} = 0.684$	$p_{D1} = 0.000$
		DT:	61%				
	D2	IT:	64%	D2	$p_w = 0.930$	$r_{D2} = 0.622$	$p_{D2} = 0.000$
		DT:	66%				
	D3	IT:	83%	D3	$p_w = 0.385$	$r_{D3} = 0.558$	$p_{D3} = 0.001$
		DT:	80%				
RRQs	D1	IT:	66%	D1	$p_t = 0.928$	$r_{D1} = 0.664$	$p_{D1} = 0.000$
		DT:	66%				
	D2	IT:	75%	D2	$p_w = 0.351$	$r_{D2} = 0.606$	$p_{D2} = 0.000$
		DT:	74%				
	D3	IT:	84%	D3	$p_w = 0.398$	$r_{D3} = 0.805$	$p_{D3} = 0.000$
		DT:	82%				

Note: DT = Delayed Test; IT = Immediate Test; MRQ = Meaning Recall Question; p_t = *p*-values of *t*-test; p_w = *p*-values of WSR test; PRQ = Position Recall Question; RRQ = Radical Recall Question; WSR test = Wilcoxon Signed-Rank test

Table 7-4 shows the results of the average per cent accuracy of writing SRs with D1, D2 and D3 in the IT and DT. It also shows the results of the SW test and WSR test in the IT and the DT. The results of accuracy in the IT showed that D3 (97%) had a significantly higher accuracy than D1 (79%, $p_{D1\text{-}D3} = 0.000 < 0.01$) and D2 (87%, $p_{D2\text{-}D3} = 0.004 < 0.01$). D2 (87%) had significantly higher accuracy than D1 ($p_{D1\text{-}D2} = 0.018 < 0.05$). The results of the accuracy in the DT showed that D1 (46%), D2 (47%) and D3 (55%) had no significant difference, as all the *p*-values of WSR test were larger than 0.05 ($p_{D1\text{-}D2} = 0.772$, $p_{D2\text{-}D3} = 0.099$, $p_{D1\text{-}D3} = 0.253$).

Table 7-4. The results of average per cent accuracy of writing with D1, D2 and D3, and the results of SW test and WSR test.

Questions	**Test**	**Sample**	**Accuracy**	**SD**	**SW Test**	**Compare Samples** (WSR Test)
Writing	IT	D1	79%	17%	p =0.003	p_{D1-D2} =0.018
		D2	87%	15%	p =0.000	p_{D2-D3} =0.004
		D3	97%	7%	p =0.000	p_{D1-D3} =0.000
	DT	D1	46%	26%	p =0.085	p_{D1-D2} =0.772
		D2	47%	26%	p =0.025	p_{D2-D3} =0.099
		D3	55%	26%	p =0.031	p_{D1-D3} =0.253

Note: DT = Delayed Test; IT = Immediate Test; SD = Standard Deviation; SW test = Shapiro-Wilk; WSR test = Wilcoxon Signed-Rank test

Table 7-5 shows the results of the WSR test for comparing the accuracy of writing in the IT and DT. The results showed that all the accuracy in the IT had a significant decrease, as all the *p*-values were smaller than 0.01.

Table 7-5. The results of WSR test for comparing the average per cent accuracy of writing in IT and DT.

Question	**Sample**	**Test**	**Accuracy**	**Compare IT and DT** (WSR test)
Writing	D1	IT	79%	p_{D1} = 0.000
		DT	46%	
	D2	IT	87%	p_{D2}= 0.000
		DT	47%	
	D3	IT	97%	p_{D3} = 0.000
		DT	55%	

Note: DT = Delayed Test; IT = Immediate Test; WSR test = Wilcoxon Signed-Rank test

Table 7-6 lists the number of different types of errors that were occurred in the IT and DT when writing with D1, D2 and D3. In Table 7-6, Error Type 1 is writing SRs with wrong stroke order. Error Type 2 is wrong stroke directions. Error Type 1 & 2 is writing SRs with both wrong stroke order and wrong stroke directions.

In the IT, the results of D1 showed that 17 participants had Error Type 1, 27 participants had Error type 2, and nine participants had Error Type 1&2. The results of D2 showed that two participants had Error Type 1, 26 participants had Error type 2, and one participant had Error Type 1&2. Comparing D1 and D2, the number of Error Type 1 was dramatically decreased, and the Error Type 2 still had a certain number. The results of D3 showed that three participants had Error Type 1, three participants had Error type 2, and no participant had Error Type 1&2. Both of the Error Type 1 and Error Type 2 had a remarkable decrease. In the DT, the results of D1, D2 and D3 all showed a certain number of all types of errors, as the accuracy in the DT significantly decreased.

Table 7-6. The number of different types of errors that were occurred in IT and DT when writing with D1, D2 and D3.

	Accuracy & Error Type	**D1**	**D2**	**D3**
IT	**Accuracy**	**79%**	**87%**	**97%**
	Error Type 1	17	2	3
	Error Type 2	27	26	3
	Error Type 1&2	9	1	0
DT	**Accuracy**	**46%**	**47%**	**55%**
	Error Type 1	61	57	56
	Error Type 2	46	53	36
	Error Type 1&2	18	14	15

Note: DT = Delayed Test; Error Type 1 = wrong stroke order; Error Type 2 = wrong stroke directions; IT = Immediate Test

Table 7-7 shows the results of the average answering speed when learning with each sample in the IT and DT and the results of the WSR test or *t*-test for comparing the results of each sample. The results in the IT showed that the participants answered questions of D3 (225s) with a significantly faster speed than that of D1 (275s, $p_{w.D1\text{-}D3}$= 0.006 < 0.05) and D2 (285s, $p_{t.D2\text{-}D3}$= 0.004 < 0.05). The results in the DT for all the three samples showed no significant difference, as all the *p*-values were larger than 0.05 (refers to Table 7-7).

Table 7- 8 shows the results of the writing speed when learning with each sample in the IT and DT and results of the WSR test or *t*-test for comparing the average writing speed in the IT and DT. The results showed that the participants wrote SRs with a significantly faster speed in the DT than that in the IT, as all the *p*-values were smaller than 0.01 (refers to Table 7-8).

Table 7-7. The results of the average answering speed in IT and DT and the results of the WSR test or *t*-test for comparing samples D1, D2 and D3.

	Sample	Speed (s)	SD(s)	SW Test	Compare Samples (WSR test/ *t*-test)	
IT	D1	275	85	p =0.026	D1-D2	$p_w = 0.704$
	D2	283	84	p =0.162	D2-D3	$p_t = 0.004$
	D3	225	62	p =0.057	D1-D3	$p_w = 0.006$
DT	D1	205	73	p =0.000	D1-D2	$p_w = 0.411$
	D2	189	45	p =0.779	D2-D3	$p_t = 0.546$
	D3	185	43	p =0.908	D1-D3	$p_w = 0.069$

Note: DT = Delayed Test; IT = Immediate Test; p_t = *p*-values of *t*-test; p_w = *p*-values of WSR test; SD = Standard Deviation; SW test = Shapiro-Wilk; WSR test = Wilcoxon Signed-Rank test

Table 7-8. The results of the WSR test or *t*-test for comparing the average answering speed in IT and DT.

Sample	Test	Speed (s)	Compare IT and DT (WSR test or *t*-test)
D1	IT	275	$p_{w\ D1} = 0.000$
	DT	205	
D2	IT	283	$p_{t\ D2} = 0.000$
	DT	189	
D3	IT	225	$p_{t\ D3} = 0.000$
	DT	185	

Note: DT = Delayed Test; IT = Immediate Test; p_t = *p*-values of *t*-test; p_w = *p*-values of WSR test; SD = Standard Deviation; WSR test = Wilcoxon Signed-Rank test

7.3.2.2 The results of the post-test survey in Study 5

Table 7-9 shows the percentage of participants who chose D1, D2 or D3 as the easiest VIs for Reading & Memorising SRs and the easiest VIs for writing SRs separately, in terms of Q1, Q2, Q3 and Q4 and the average of them. Regarding VIs for Reading & Memorising SRs, most of the participants (76%) chose sample D3. In terms of VIs for writing SRs, the majority (75%) of the participants chose sample D3.

Table 7-9. The percentage of the participants who chose D1, D2 or D3 as the easiest VIs for Reading & Memorising or VIs for writing for Q1, Q2, Q3, Q4 and the average of them.

VIs	Sample	Q1	Q2	Q3	Q4	**Average**
Reading & Memorising	D1	7%	3%	3%	10%	**6%**
	D2	20%	10%	27%	17%	**19%**
	D3	73%	87%	70%	73%	**76%**
Writing	D1	10%	3%	10%	3%	**7%**
	D2	10%	27%	20%	17%	**19%**
	D3	80%	70%	70%	80%	**75%**

Note: Q = Question; VI = Visual Instruction

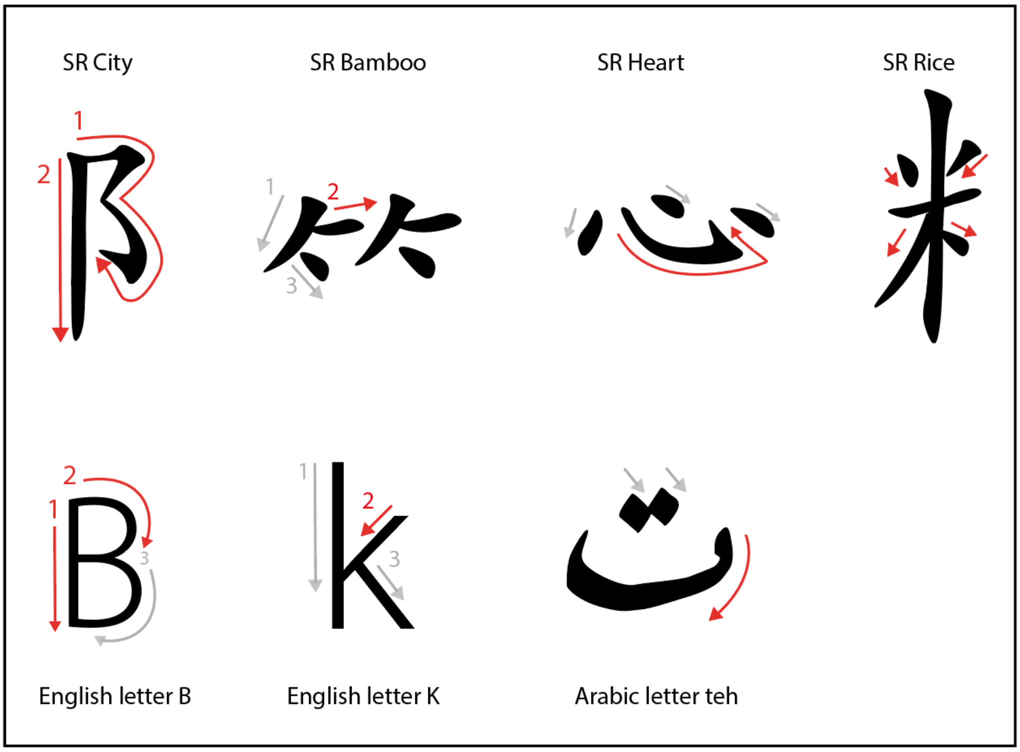
For the functions of the integrated illustrations, most of the participants agreed that integrated illustrations helped **visualise the meanings** of SRs (agree: 26.7%, strongly agree: 66.7%) and helped **memorise the shapes** of SRs (agree: 30%, strongly agree: 60%). Regarding the functions of the colour coding, most of the participants agreed that colour coding helped **memorise the positions** of SRs (agree: 26.7%, strongly agree: 60%), **split the compound CCs into parts** (agree: 40%, strongly agree: 43.3%) and **highlight SRs in compound CCs** (agree: 26.7%, strongly agree: 60%).

During the writing task, it was noted that when the VIs did not provide arrows (D1 and D2) to inform the writing directions, the participants wrote strokes in the directions according to their own understanding or habits. Moreover, some participants wrote strokes in the directions and order basing on their own understanding or habits because they could not remember the VIs clearly in the DT. Some SRs were repeatedly written in wrong ways by seventeen participants. Therefore, they were asked possible reasons or basis why they wrote some SRs in that particular way. Six reasons were found: L1 writing habits, misunderstanding of stroke shapes, habits of left-handed users, an illusion of Asian writing system, random choices and personal habits.

First, four participants stated that they wrote some SRs in the way basing on their L1 writing habits, especially when some SRs showed similar shapes with the scripts of their language. Three British of the four participants and one Arabic participant gave examples to support this idea. Participants S5P2, S5P9 and S5P18 (British) stated that SR City had a very similar shape with the English letter B, and SR Bamboo looked like two English letters K (Figure 7-8). Participant S5P16 (Arabian) stated that SR Heart looked similar with Arabic letter teh (Figure 7-8). However, the stroke order of SR City and English letter B is opposite, as shown in Figure 7-8. The vertical stroke should be written first in letter B, while it is the second stroke in SR City. The red highlighted stroke direction of SR Bamboo and letter K is opposite (Figure 7-8). The red highlighted stroke direction of SR Heart and Arabic letter teh is opposite (Figure 7-8). Therefore, they wrote the SRs inaccurately if they followed the writing habits of their L1.

Second, four participants misunderstood the stroke shapes. Participants S5P5 and S5P7 stated that they wrote them following the shapes of strokes from thick to thin. S5P2 and S5P8 followed the shape from thin to thick. However, the shapes of strokes do not indicate directions. For example, the four strokes of SR Rice (Figure 7-8) have different directions, which are inconsistent with stroke shapes (thin-to-thick or thick-to-thin).

Third, two participants were left-handed, as they had a habit of writing from right to left. Fourth, two participants had an illusion of Asian culture. Participant S5P21 said that he had an impression that Asian writing was from right to left. Participant S5P3 said that she felt CCs were very different from English; therefore, she would like to write it differently. Last, two participants said that keeping writing from right to left or from bottom to top was random choices. Three participants stated that consistent writing directions or order of some strokes were their personal habits.



Note: SR = Semantic Radical

Figure 7-8. SRs City, Bamboo, Heart and Rice, English letters B, K and Arabic letter teh.

7.3.2.3 The results of the participants' spontaneous comments in Study 5.

Nineteen of the 30 participants talked to themselves or expressed their opinions during the learning and testing process. The participants were informed not to interrupt if not necessary, but they were not asked to keep quiet. Expressing opinions or talking to themselves were acceptable as long as their behaviours did not interrupt the learning and testing process. Therefore, the participants' spontaneous comments during the study were noted. Moreover, some participants expressed their opinions or explained the reasons for choosing the specific option when they did the post-test survey. Thus, these ideas were also noted.

The participants commented on the integrated illustrations (D2 and D3). The comments about illustrations were categorised and listed below with examples:

Seven participants stated that some illustrations came to their minds when they saw SRs in the memory test. For example, S5P4 said, 'I have to agree with that the illustrations underneath helped memorise because when I did the test, some of them came to my mind, but not all of them.' S5P7 said, 'The illustrations highlighted the shapes, when I did the test, the pictures sometimes came to my mind' and S5P8 said, 'The pictures (illustrations) made a difference, the pictures definitely remind me when I did the test'. Three of the seven participants expressed this idea more directly during the test, like S5P9 said, 'I do remember the bird illustration underneath.' and S5P18 said, 'I think this one is slow-walk radical, because I remember it was an old lady (the illustration for SR Slow-walk).'

Nine participants indicated that illustrations were interesting, engaging and motivated them to learn the Chinese language. For example, S5P3 said, 'The amazing pictures (illustrations) help you to understand what you are learning, and where the shape comes to be, like the bird, the old person, and the bamboo. Then you want to know more about it, you want to know the stories behind them.' S5P9 said, 'The diagrams (illustration) were quite humorous. I think it depends on the person, honestly. For example, I am a funny person, I like jokes and kidding around stuff, and I found the illustration of the knife and the grandma were quite humorous. I was much more likely to remember them.' S5P29 said, 'I don't know if I can remember them all, but I found the pictures are so interesting and beautiful.'

Two participants preferred to learn SRs without illustrations. S5P12 said, 'Some illustrations around seem to conflict with that, so kind of confuse me a bit, especially those with many colours. I prefer the simplest one.' S5P28 said, 'I like to create my own pictures. I don't like to use other people's pictures.'

The participants commented on the colour-coded illustrations (D3). The comments were categorised and listed below with examples:

Six participants indicated that the colour-coded integrated illustrations were more informative than the integrated illustrations, especially for informing the position of SRs. For example, S5P2 said, 'I think this one (D3) was the easiest because that one (D2) has too many colours. It is beautiful, but I can't remember them clearly. This one (D3), the orange goes with sides (positions), I could remember where it belongs to.' S5P18 said, 'Definitely this one (D3). I think the colour showed it belongs to the top, to the bottom. I feel like I could remember more when it is colour-coded.' S5P29 said, 'The colour coding breaks down the characters for me because it just looks like a big picture when it is all black.'

Five participants said that the colour-coded integrated illustrations were easy to recall. For example, S5P10 explained, 'When I learnt with the colour coding, I felt like I can do with colours. I remember all the colours. That definitely worked for me.', and S5S18 said, 'I think I got the colours in my head.'

Three participants doubted the effect of the colour-coded integrated illustrations. For example, S5P23 said, 'For many of them, I prefer the one with colour coding because it is informative. But for the others, for example, the Radical Bamboo, I felt if it was green. It would be easier to remember if it is green because it is related.', and S5P26 said, 'I agree with that the colour coding helped, but I don't think it works on long-term memory.'

Two participants disagreed with the effect of colour coding. For example, S5P16 said, 'I definitely like the illustrations, but to be honest, I didn't pay attention to the colour.' S530 said, 'Colour just did not do anything for me.'

The participants commented on the colour hints (D2, S3) and arrows (S3) separately for VIs for writing SRs. The comments were categorised and listed below with examples:

Three participants stated that the colour hints clearly inform the stroke order. For example, S5P3 said, 'The colour definitely made it easier to follow and easy to understand. The black one is the one you've got already, and the red one shows the one you need to do.'

Four participants stated that arrows were necessary, as they clearly informed the writing directions. For example, S5P7 said, 'When you wrote it the first time, the arrows kind of gave a symbol. I think it was helpful.' S5P21 said, 'Some strokes, even with colours, you don't know which way they are going.'

S5P25 said, 'When I wrote without arrows, I'm getting confused, like, shall I write from top to bottom or from bottom to top?'

Three participants stated that arrows were unnecessary, and the arrows increased the visual complexity of VIs. For example, S5P2 said, 'The instructions with arrows look a bit complex for me. I felt like I knew the directions. I don't need the arrows.' S5P9 said, 'I think the one with arrows were complex sometimes. They made me write slowly.'

7.4 Discussion

The aim of Study 5 was to examine the effectiveness of VIs for Reading & Memorising SRs and VIs for writing SRs together in the IT and DT. The results of Study 5 rejected the null hypothesis that VIs have no effect on memorising SRs after reading and writing with VIs.

The **integrated illustrations** with SRs showed significant benefits for recalling the meanings and shapes of SRs. The results of the memory test, post-test survey and spontaneous comments all supported this finding. Participants got a significantly higher accuracy for recalling the meanings (MRQs) and shapes (RRQs) of SRs when they learnt SRs with integrated illustrations than learning SRs without integrated illustrations in the IT and DT. The results align with the cognitive load theory that the integration of multiple information increases the effect of VIs and is easy to remember (Chandler and Sweller, 1996; Ayres and Sweller, 2005; Sadoski and Paivio, 2013), and illustrations foster memory (Szlichcinski, 1980; Gombrich, 1990; Horn, 1998; Male, 2017; Samara, 2007; Hall, 2011; Pettersson, 2015a). Most of the participants also showed positive opinions about the effect of using illustrations as mnemonics in the post-test survey and the comments. The results of the post-test survey confirmed that the integrated illustrations had the functions of visualising meanings of SRs and enhancing memorisations, as those two functions were also suggested in the literature review (Paivio, 1969; Szlichcinski, 1980; Gombrich, 1990; Male, 2017; Defeyter et al., 2009; Hall, 2011; Curran and Doyle, 2011).

Comparing the results of Study 3 and Study 5, Table 7-10 lists the consistent and inconsistent results for the effect of integrated illustrations. The results showed that integrated illustrations had a significant benefit for memorising (IT and DT) the meanings of SRs that were consistent in Study 3 and Study 5. The results of Study 3 and Study 5 were inconsistent in terms of the effects of integrated illustrations for memorising the shapes of SRs in DT and memorising the positions of SRs in IT and DT.

Table 7-10. The consistent and inconsistent results in Study 3 and Study 5 for the effect of integrated illustrations.

Consistent results in Study 3 and Study 5	
1	Learning SRs with integrated illustrations significantly increased the accuracy of memorising meanings and shapes of SRs in the IT and DT (at least seven days).
2	The high accuracy of memorising meanings of SRs showed no significant decrease in DT.
Inconsistent results in Study 3 and Study 5	
1	Study 3: the high accuracy of memorising shapes of SRs showed a significant decrease in DT. Study 5: the high accuracy of memorising shapes of SRs showed no significant decrease in DT.
2	Study 3: learning with integrated illustrations significantly increased the accuracy of memorising positions of SRs. Study 5: learning with integrated illustrations showed no effect on memorising positions of SRs.

Note: DT = Delayed Test; SR = Semantic Radical; IT = Immediate Test

Two possible reasons could explain the inconsistent results of integrated illustrations for memorising the shapes of SRs in DT. Firstly, the learning task in Study 5 included both reading and writing, which were stronger than that in Study 3 (only reading). Thus, the effect of memorising the shapes of SRs with integrated illustrations might be strengthened by the writing practice. Secondly, VIs for Reading & Memorising SRs in Study 5 were adjusted and improved, the effect of memorising was reasonably improved. These two reasons might explain why the high accuracy of memorising the shapes of SRs showed no significant decrease in DT in Study 5, while it showed a significant decrease in DT in Study 3.

A possible reason could explain the inconsistent result of integrated illustrations for memorising the positions of SRs. The effect of illustrations on memorising the positions of SRs was not significant and remarkable when the sample of SRs was expanded and shifted among the participants in Study 5. In other words, the effect for memorising positions of SRs might be weakened when the sample of SRs was expanded and shifted.

The **colour-coded integrated illustrations** did not weaken the effectiveness of illustrations for memorising the meanings and shapes of SRs, but significantly improved the effect on memorising the positions of SRs in IT and DT. The results are in line with the literature review that colour coding is an effective tool for enhancing memory in VIs (Peck and Hannafin, 1988; Bradshaw, 2003; Samara, 2007; Pettersson, 2013c; 2015a; 2015b). However, the colour-coded integrated illustrations showed significantly higher accuracy than integrated illustrations in Study 3 (in IT) and Study 5 (in IT and DT). The reason might be that the improvement of VIs in Study 5 increased and lasted the effect on memorising. Moreover, the writing practice might also enhance the memorising of positions of SRs. The results of the post-test survey and the participants' comments also showed that most participants recognised the significant effect of the colour-coded integrated illustrations for enhancing memorising the positions of SRs.

Regarding the **VIs for writing SRs**, Study 5 proved the significant effect (high accuracy) of colour hints and arrows in writing VIs for memorising (IT) the stroke order and stroke directions. The stroke-by-stroke VIs with colour hints dramatically reduced the error numbers of wrong stroke order when writing SRs in the memory test. The stroke-by-stroke VIs with arrows significantly decreased the error numbers of wrong stroke directions when writing SRs in the memory test.

The functions of colour hints and arrows for writing SRs in the memory test were in accordance with the results of Study 4 for writing practice. The effect and functions of colour hints in VIs for writing SRs are in agreement with the literature review. Colour is suggested as a useful tool in instructions for enhancing memory (Pettersson, 2010; 2014; 2019), increasing attention (Winn, 1993; Mijksenaar, 1997; Pettersson, 2015a; 2019) and boosting distinctions (Mijksenaar, 1997; Pettersson, 2019). The effect of colour hints in writing VIs well reflected these functions of colour. The functions of arrows in writing VIs are in keeping with the findings in the literature review. Arrows are recommended to indicate directions and suggest movement in instructions (Horton, 1993; Horn, 1998; Pettersson, 2013a). However, the effect of writing VIs with colour hints and arrows cannot stay long without practising, as the high accuracy for writing in the memory test greatly reduced in DT.

Therefore, an explicit and effective writing VIs can significantly improve the accuracy of writing and the short-term memory of writing rules, but the long-lasting memory of writing still need practising. Accurately writing SRs at the beginning of learning is also significant, which could avoid forming the habit of writing SRs in a wrong way in the early stage of learning.

The **answering speed** was the sum of time for answering MRQ, PRQ, RRQ and writing together of individual SRs. The MRQ, PRQ and the writing of an SR were displayed on one page in Study 5. In this way, the participants could think different questions (MRQ, PRQ and writing) about an SR as a whole. Therefore, the specific time for answering individual questions was not counted, while only the sum of time for individual SRs was reported in Study 5.

The answering speed was reported differently in Study 3 and Study 4 because of different formats of questions. In Study 3, all questions were MCQs, which were suitable for counting time period of answering individual questions.

The results of the answering speed in Study 5 showed that the participants answered questions of D3 with a significantly faster speed than that of D1 and D2 in the IT. Sample D3 showed SRs with colour-coded integrated illustrations and writing VIs with colour hints and arrows. The results showed that the answering speed of D1 and D2 was not a significant difference in IT. Sample D2 showed SRs with integrated illustrations and writing VIs with colour hints, and sample D1 showed SRs with simple VIs.

The results of the answering speed in Study 5 were inconsistent with the results of Study 3. Counting the writing speed as a part of the answering speed in Study 5 might be the possible reason. The answering speed reported in Study 5 included all the three MCQs and the writing of the 21 SRs, while Study 3 only reported the answering speed of the three MCQs. Thus, the writing speed in the answering speed was a variable. The results of Study 3 showed that the participants used a significant faster speed for answering questions of SRs showed with integrated illustrations than SRs showed with simple VIs. Counting the writing time together in the results of the answering speed might explain why Study 5 showed no significant difference in terms of answering speed for D1 and D2.

However, the results of answering speed in Study 5 showed that the participants used a significantly faster answering speed for D3 than D1 and D2. The reason might contribute from that the colour-coded integrated illustration (D3) showed SRs in a more effective way than D1 and D2. The participants remembered SRs with D3 clearer and answered the related questions faster. The VIs D3 for writing was also the suggested VIs and showed the highest accuracy. Thus, the participants used a significantly faster speed for D3. Therefore, the results of the answering speed in the IT provided additional evidence for supporting the effectiveness of D3 for Reading & Memorising and writing SRs.

In terms of the answering speed in DT, the participants used a significantly shorter time for answering all the questions than the IT, since it was the second time that the participants did the same memory test. Therefore, participants needed a shorter time for doing the memory test.

However, the answering speed of the three samples showed no significant difference. That is to say, the effect for fast answering questions of D3 could not stay long.

In terms of the **participants' subjective opinions** (results of the post-test survey and the participants' spontaneous comments), the results showed that the participants hold various views about different VIs. From the results of the post-test survey, most participants showed positive opinions in terms of VIs. However, some participants held negative ideas. For example, some participants thought that the integrated illustrations conflicted with SRs, and some participants felt colour coding did not affect them. There is no denying that people have different acceptability of illustrations and colours. It is almost impossible that one type of VIs applies to everyone. The results of the memory test showed that the VIs of Reading & Memorising SRs sample D3 was effective for most participants.

For VIs of writing SRs, most participants showed positive opinions about D3 (colour hints and arrows). However, some participants held negative opinions about displaying with arrows, because the arrows inevitably increased the visual complexity and slowed down the speed of reading VIs and writing SRs. The results of the post-test survey showed that many participants mistakenly thought they knew the directions of writing strokes. Some participants illustrated that many different factors influenced their decisions on the directions of writing strokes, such as their L1. The application of arrows showed the directions of strokes clearly and significantly increased the accuracy of writing SRs.

7.5 Conclusions

Study 5 examined the effectiveness of the three VIs for Reading & Memorising SRs (D1: simple VIs; D2: integrated illustrations; D3: colour-coded integrated illustrations) and the three VIs for writing SRs (D1: simple VIs; D2: VIs with colour hints; D3: VIs with colour hints and arrows). The results of Study 5 showed that sample D3 had apparent advantages over samples D1 and D2 in most situations.

Regarding VIs for Reading & Memorising SRs, D3 showed significantly higher accuracy of answering PRQs than D1 and D2 in the IT and DT. The accuracy of answering PRQs of D1 and D2 showed no significant difference. The result demonstrated that colour coding significantly increased the accuracy of memorising the positions of SRs in CCs. For answering MRQs and RRQs, samples D2 and D3 showed significantly higher accuracy than D1 in both IT and DT. The accuracy of D2 and D3 showed no significant difference. The results showed evidence that integrated illustrations significantly increased the accuracy of memorising meanings and shapes of SRs in both IT and DT. The results of the accuracy in IT and DT showed no significant difference and a positive correction, which means that the effect of VIs could stay at least seven days. Although some participants held negative views about colour coding and integrated illustrations, most participants believed the effectiveness of the colour coding and integrated illustrations for enhancing learning SRs.

For VIs for writing SRs, D3 showed significantly higher accuracy than D1 and D2 in IT. D2 had a significantly higher accuracy than D1 in the IT. The results of the error types of writing SRs, participants had a relatively high number of both Error Type 1 (Wrong stroke order) and Type 2 (Wrong stroke directions) when learning with D1. The number of Error Type 1 significantly decreased when learning with D2, but the number of Error Type 2 was still relatively high. The number of Error Type 1 and Error Type 2 dramatically decreased when learning with D3. The results provided evidence that colour hints in stroke-by-stroke VIs significantly reduced the number of wrong stroke order for writing SRs in IT. The arrows in the stroke-by-stroke VIs significantly decreased the number of wrong stroke directions for writing SRs in IT. However, the accuracy of all the three samples (D1, D2 and D3) showed a significant decrease in DT, and they showed no significant difference in DT. The results of DT showed that the effect of colour hints and arrows in stroke-by-stroke VIs for writing could not stay a long time without extra practice and review.

In summary, VIs for Reading & Memorising SRs and VIs for writing SRs of sample D3 significantly increased the accuracy of memorising and writing SRs and significantly increased the answering speed in the memory test.

8 Conclusions and discussion

This study investigated the effectiveness of VIs for enhancing learning CCs by non-specialist beginners, including four specific objectives.

The first objective was to explore the basic knowledge of CCs and the real-life context for learning and teaching CCs. Literature review looking at the knowledge of CCs, interviews with students and teachers, and observation of a Chinese course in **Chapter 3**, were conducted to achieve the first objective. The study in Chapter 3 indicated that the exploration of VIs for enhancing SRs for non-specialist beginners was essential and meaningful for learning Chinese as an L2.

The second objective was to investigate the theories of the effectiveness of VIs and survey the existing cases by using VIs for learning CCs. Literature review of the effectiveness of VIs and visual survey of existing cases were conducted in **Chapter 4** to achieve the second objective. The study in Chapter 4 showed that various design elements had different functions and effectiveness for enhancing learning in theory. Various design elements for enhancing learning CCs were applied in the existing cases.

The third objective was to examine the effectiveness of different VIs for Reading & Memorising SRs. Study 1, Study 2 and Study 3 in **Chapter 5** were conducted to achieve the third objective. Study 1 explored the effectiveness of VIs for Reading & Memorising SRs in existing cases. Study 2 developed a new design of VIs for Reading & Memorising SRs. Study 3 examined the effectiveness of the new design of VIs for Reading & Memorising SRs. The results of Study 3 showed that integrated illustrations and colour coding were effective VIs for Reading & Memorising SRs. The integrated illustrations showed significantly high accuracy and fast speed in answering MRQs, PRQs and RRQs. The integrated illustrations showed the functions of visualising meanings of SRs and assisting in memorising the shapes of SRs. The colour coding showed significantly high accuracy and fast speed in answering PRQs. The colour coding showed the functions of enhancing the memory of positions of SRs by splitting the compound CCs into parts and highlighting SRs in CCs. The colour-coded integrated illustrations showed significantly higher accuracy than integrated illustrations in terms of memorising positions of SRs in IT.

The fourth objective was to examine the effectiveness of different VIs for writing SRs. The design development and examination in Study 4 in **Chapter 6** achieved the fourth objective. The results of Study 4 showed that the stroke-by-stroke VI with colour hints and arrows was significantly effective for practising writing SRs accurately, in terms of high accuracy. The application of colour hints in the stroke-by-stroke VI significantly reduced the number of errors for writing SRs with inaccurate stroke order. The application of arrows in the stroke-by-stroke VI dramatically reduced the number of errors for writing SRs with inaccurate stroke directions.

Study 5 in Chapter 7 further examined the effectiveness of VIs for Reading & Memorising SRs and VIs for writing SRs together, which referred to the third and the fourth objectives. The results of Study 5 showed that the VI of colour-coded integrated illustrations was significantly more effective, in terms accuracy and answering speed, than the VI of integrated illustrations for Reading & Memorising SRs in both IT and DT. The stroke-by-stroke VI with colour hints and arrows for writing SRs was significantly effective, in terms accuracy, for memorising writing rules of individual SRs than the VI with colour hints only or the VI without colour hints and arrows in IT.

8.1 Major findings

This study provides evidence for effective VIs for Reading & Memorising SRs and also for writing SRs, which are supported by the results of the various experimental studies conducted. This study also provides evidence for the effectiveness of information and instructional design, especially in learning applications. The mixed and user-centred research methods help to provide further evidence to support the importance of this study, which can be applied to other research in the field of Design in general, and Information and Instructional Design more specifically. The major findings are discussed next by linking them to the literature in order to show how they strengthen previous research and advance knowledge further.

8.1.1 Major findings in effective VIs for Reading & Memorising and writing SRs

Regarding VIs for Reading & Memorising SRs, **integrated illustration is a significantly effective VI approach for enhancing Reading & Memorising the meanings and shapes of SRs.** The results of Study 1 showed that integrated illustrations in existing cases have potential effectiveness (high accuracy) for enhancing Reading & Memorising the meanings and shapes of SRs. The results of Study 3 showed that the developed VI with integrated illustrations significantly increase the accuracy and speed of Reading & Memorising the meanings, shapes and positions of SRs. The results of Study 5 showed that integrated illustrations significantly increase the accuracy of Reading & Memorising the meanings and shapes of SRs with an expanded sample size of SRs. The results of Study 1, Study 3 and

Study 5 demonstrated that integrated illustrations significantly increase the effectiveness, in terms of accuracy, of Reading & Memorising the meanings and shapes of SRs. The integrated illustrations significantly enhance the memorising positions of SRs and significantly increases the speed of answering questions in Study 3, but the effects are weakened in Study 5. Therefore, those two points of effectiveness are not claimed.

The finding is in line with the dual coding theory and the picture superiority effect that presenting information with pictures and texts makes it easier to remember than presenting texts only (Paivio, 1986; Clark and Paivio, 1991; Pettersson, 2014). It is also consistent with the design suggestions that the use of illustrations enhances memory in VIs (Peeck, 1993; Horn, 1998; Male, 2017; Hall, 2011). The function of the integrated illustrations for increasing the effectiveness of VIs is in line with the literature claiming that illustrations are used for visualising objects (Szlichcinski, 1980; Gombrich, 1990; Horn, 1998; Male, 2017; Hall, 2011). Moreover, the cognitive load theory suggests that the integration of multiple information increases the effectiveness of processing information and is easy to remember (Chandler and Sweller, 1996; Ayres and Sweller, 2005; Sadoski and Paivio, 2013). The first major finding is also in line with the suggestion of the cognitive load theory that the integration of illustrations and SRs significantly increase the effectiveness of memorising SRs. The design suggestions, the dual coding theory, the picture superiority effect and the cognitive load theory all explain why the integrated illustrations have a significant efficiency for enhancing learning SRs.

Compared with previous studies that had a similar focus, this study is one of the first studies showing significant effectiveness of images (integrated illustrations) in long-term memory (at least seven days). Previous studies reported no significant effectiveness of images in long-term memory (e.g., Wang and Thomas, 1992; Lai and Newby, 2012). In this study, the results of Study 3 and Study 5 are evidence to support the effectiveness of integrated illustrations in long-term memory.

There are two possible reasons to explain why this study shows significant effectiveness of images in long-term memory while the other studies do not. First, this study explored integrated illustrations rather than a wide concept of images. As discussed above, the cognitive load theory suggests that integrating multiple sources of information in VIs is effective for learning and memory (Chandler and Sweller, 1996; Ayres and Sweller, 2005; Sadoski and Paivio, 2013). Second, the integrated illustrations were designed based on visual perception principles (details in Section 4.2.2), i.e., simplicity, similarity, focal point and contrast principles (Chang et al., 2002; Lipton, 2011; Ali and Peebles, 2013; Pettersson, 2014; Lonsdale and Lonsdale, 2019). The visual perception principles suggest several theories of presenting visual elements, which facilitate the effectiveness of VIs. Integrated illustrations reasonably show longer effect in memory than a wide concept of images.

Colour coding is a significantly effective VI approach for enhancing Reading & Memorising positions of SRs. Thus, the colour-coded integrated illustration is a significantly effective VI approach for enhancing Reading & Memorising the meanings, shapes and positions of SRs. The results of Study 1 showed that the colour coding in existing cases has potential effectiveness (high accuracy) for assisting in Reading & Memorising the positions of SRs. Study 2 developed samples of a VI with colour coding and a VI with colour-coded integrated illustrations. The results of Study 3 and Study 5 showed that the colour coding (only in Study 3) and the colour-coded integrated illustrations significantly increase the accuracy and speed of Reading & Memorising the positions of SRs. Compared with previous studies that focused on a similar topic, this study is one of the first studies that tests the effectiveness of VIs for memorising positions of SRs. This study is also one of the first studies that explores the effectiveness of colour coding for learning SRs. It finds that both colour coding and colour-coded integrated illustrations significantly increase the effectiveness of memorising positions of SRs.

The finding is consistent with the suggestion that colour coding is a powerful mnemonic tool in VIs (Peck and Hannafin, 1988; Bradshaw, 2003; Samara, 2007; Pettersson, 2013c; 2015a) and using colour is effective to boost attention and clarity in VIs (Winn, 1993; Mijksenaar, 1997; Pettersson, 1998; 2010; 2019; Olurinola and Tayo, 2015). The colour-coded integrated illustration has concise style illustrations in a monochromatic colour, which is clear to read and understand. The design of the VI adheres to the simplicity principle in visual perception (Mullet and Sano, 1995; Dewar, 1999; Lipton, 2011). The colour of the illustrations, the colour of the SRs in related CCs and the colour of the squares are the same, or at least in the single hue (monochromatic colour) in the VI of colour-coded integrated illustration. The VI adheres to the similarity principle in the visual perception, which indicates that visual elements with similar colours are easy to perceive as a group and facilitates the processing of information (Chang et al., 2002; Lipton, 2011; Ali and Peebles, 2013; Pettersson, 2014; Lonsdale and Lonsdale, 2019). The consistency between the VI and the simplicity principle and the similarity principle also explains the effectiveness of the VI for enhancing memorising the positions of SRs.

Regarding VIs for writing SRs, **colour hints in stroke-by-stroke VI for writing SRs significantly increase the accuracy of writing SRs and decrease the numbers of writing SRs with inaccurate stroke order.** The results of Study 4 showed that the colour hints in stroke-by-stroke VI significantly increase the accuracy of practising writing SRs and decrease the number of inaccurate stroke order. Participants had intuitive senses of the colour hints because the colour hints were not explained to them in Study 4 and Study 5. Picking out one stroke as a whole is difficult for beginners, especially when many different shapes of strokes were joint together. This finding is aligned with the suggestion that colour increases attention, clarity and shows different levels of information in VIs (Winn, 1993; Mijksenaar, 1997; Pettersson, 1998; 2010; 2019; Olurinola and Tayo, 2015). Therefore, colour hints in stroke-by-stroke VIs significantly increase the accuracy of writing practice. The results of Study 5 showed that colour hints in stroke-by-stroke VI greatly increase the accuracy of writing recall and decrease the number of inaccurate stroke order in IT. Colour is recommended as a powerful mnemonic tool in VIs (Pettersson, 2010; 2014; 2019), which explains why colour hints significantly increase the effectiveness of writing recall.

Arrows in stroke-by-stroke VI for writing SRs significantly increase the accuracy of writing SRs and decrease the numbers of writing SRs with inaccurate stroke directions. The data of Study 4 demonstrated that the arrows in stroke-by-stroke VI significantly increase the accuracy of practising writing SRs and reduce the number of inaccurate stroke directions. The findings of Study 5 indicated that arrows in stroke-by-stroke VI significantly increase the accuracy of writing SRs and memorising the writing rules of individual SRs. There was also a significant reduction in the number of writing SRs with inaccurate stroke directions in the memory test (IT). The finding is in line with the literature claiming that arrows indicate directions and suggest movement in instructions (Horton, 1993; Horn, 1998; Pettersson, 2013a). Moreover, the fourth finding shows that the function of indicating directions in writing SRs can stay in our short-term memory. It also can be explained that participants form an accurate writing habit while practising writing SRs, and using the habit in the memory test. The results of Study 5 also showed that some participants thought arrows were not necessary. However, their writing behaviours were negatively influenced by their first language writing rules. All the evidence shows the demand and effectiveness of using arrows in writing VIs.

8.1.2 Major findings in effective information and instructional design and design research

The effectiveness of integrated illustrations for enhancing learning 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.

For example, the use of **illustrations** to enhance learning. First, illustrations in monochromatic colour show no significant difference with illustrations in chromatic colour for reading and memorising, particularly for memorising information of meanings and shapes. The results of Study 3 and Study 5 provide this evidence. While Pettersson (2019) states that chromatic colours draw more attention than achromatic colours, for reading and memorising in VIs, this study finds that illustrations in monochromatic colours (single hue) have a similar effect to illustrations in chromatic colours (multiple hues). Illustrations in monochromatic colours can be used in VIs when displaying complex visual information. This seems to be because chromatic colours with multiple hues increase visual complexity, which in turn might decrease the effectiveness of perceiving complex information.

Second, for learning purposes in VIs, instructional illustrations in vector and modern-life styles are more suitable than illustrations in hand-drawing and non-objective styles. Illustrations in hand-drawing styles, especially in traditional Chinese drawing styles (e.g., freehand brush work), are generally non-objective, which is not clear to represent objects for instructional purposes. Results of Study 1 provide this evidence. Therefore, it is suggested to use clear, concise and easy-to-recognise illustrations in VIs. It is also suggested to avoid using illustrations with excessive details and abstract styles in VIs. This suggestion is consistent with the simplicity principle (Pettersson, 2002; 2014; Lipton, 2011).

Third, integrated illustrations can be applied to acquiring knowledge in other subjects, e.g., biology, anatomy and mechanical engineering, to name only a few. For learning purposes, integrating illustrations into textual information or photos allows to present multiple information as a meaningful whole, which is easy to be understood and effective to be learnt, as it is in line with the cognitive load theory (Chandler and Sweller, 1996; Ayres and Sweller, 2005; Sadoski and Paivio, 2013).

This study shows the effectiveness of **colour coding** specifically for enhancing memorising positions of SRs. But, this study also allows to make suggestions about using colour coding for enhancing learning in general. First, colour-coded illustrations do not weaken the effectiveness of colour coding in enhancing memory. In Study 3, colour-coded illustrations show significantly higher accuracy for memorising positions of SRs than colour-coded SRs. That is to say, the combination of colour coding and integrated illustrations reinforces the effectiveness of colour coding for memorising positions of SRs in this study. It is because the colour-coded illustrations (monochromatic colour) are more informative and visually simplified than multiple chromatic colours. For a general learning purpose (not focused on learning SRs), the combination of colour coding and illustrations does not diminish the effect of colour coding. Therefore, it is suggested that colour coding can be combined with illustrations. What calls for special attention is that the colours used for colour coding and the combined illustrations, should be consistent. As stated by Pettersson (2010, 2014), mixing decorative colours and colour coding should be avoided. The results of Study 3 provide evidence that mixing illustrations in multiple chromatic colours and single hue colour coding together diminished the effect of colour coding in memory.

Second, when combining colour coding with illustrations, colours with different brightness but single hue (monochromatic colour) can be used for highlighting some necessary details in illustrations. This is so that illustrations do not lose necessary characteristics and are recognisable when combined with colour coding and monochromatic colours are applied. The VIs for Reading & Memorising in Study 2 (Sample A5), Study 3 (Sample B5) and Study 5 (Sample D3) were all designed in this way. This suggestion can also be applied in other fields in information design, such as colour coding in wayfinding design. For example, the wayfinding design and thematic illustrations in Seattle Children's Hospital have colour coding in wayfinding design and consistent monochromatic colours in the related thematic art design. The design in Seattle Children's Hospital was a Merit Award winner in the 2015 SEGD Global Design Awards (SEGD, 2015). In the hospital, the monochromatic colours with different brightness in the illustrations not only help to present details and variations, but also keep the colour hues consistent with the colour coding that shows different zones of the hospital. This means the combination of colour coding and illustrations that have the same hue monochromatic colours with the colour coding could help integrate the colour coding into the other designs or scenes and enhance the effect of the colour coding.

Likewise, the findings related to **VIs for writing** are not limited to writing SRs or CCs, because other language scripts generally have writing rules, such as the Arabic alphabet. As long as the writing scripts are required to write in fixed stroke order and directions, the stroke-by-stroke VIs with colour hints and arrows, should be effective for writing practice and writing recall by learners, especially L2 beginners. Another important finding is about layouts. The writing VIs and places for writing practice should be up-and-down layout, which is accessible for both right-handed users and left-handed users. Considering that users' hands may hinder their attention to the VIs, the suggestion is that left-and-right layout should be avoided because it is less accessible for left-handed users when VIs are on the left and vice versa.

Regarding **methodology**, this study used mixed research methods to investigate the effectiveness of VIs with users. The preliminary qualitative research (e.g. literature review, interviews and survey) identified the research gap and research questions. Then, the mixed qualitative and quantitative studies developed and examined the effectiveness of VIs for enhancing learning SRs. The experimental studies were a process of reducing design variables and expanding test samples of SRs. The mixed research methods used in this study helped to provide diverse types of evidence. For example, to measure the effectiveness of colour coding for enhancing learning, the visual survey explored the use of colour coding in existing designs, the memory tests collected the objective data (i.e., accuracy and speed) of colour coding, and the post-test survey asked participants' subjective opinions regarding colour coding. Although not all the participants agreed with the effectiveness of colour coding, most participants felt it is useful. The effectiveness of colour coding was supported by both quantitative and qualitative data. The methods used in this study can be used to explore the usability of information and instructional design in the areas of education (learning other subjects), as well as other fields like healthcare and wellbeing. Appropriate adjustments might be necessary to meet some special needs when the similar methods are used for investigating 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.

8.2 Contributions

Firstly, this study contributes to knowledge in the field of information and instructional design, by showing the significantly benefits of using VIs for read and memory. More specifically, it provides evidence that colour-coded integrated illustrations significantly improve the effectiveness of memorising SRs by non-specialist beginners, in terms of accuracy. This finding supports the effectiveness and advantage of using VIs for learning CCs as an L2, as the knowledge of SRs benefits the acquisition of the majority (about 80%) of CCs (compound CCs) (Chen, 2001; Lu, 2016). To the best of our knowledge, this is the first study to introduce the concept of colour-coded integrated illustrations with SRs, and the first to test the effectiveness of it for Reading & Memorising SRs. Previous studies (e.g., Lai and Newby, 2012, Chen et al., 2013) only tested the pictures that were next to CCs or SRs rather than integrated illustrations with SRs. Increasing the effectiveness of memorising SRs can consequently reduce the difficulty of learning Chinese language as an L2, especially for learners whose L1 is alphabetic. Moreover, improving the effectiveness of learning SRs can also increase learners' interest and motivation for learning Chinese. This study is therefore important to promote and support Chinese language education at an international level, as it improves the effectiveness of learning CCs by using VIs.

Secondly, this study suggests that the static stroke-by-stroke VIs with colour hints and arrows significantly improve the effectiveness of writing SRs by non-specialist beginners in terms of accuracy. This finding benefits the effectiveness of VIs for writing CCs, as writing SRs is an important part of the process of writing compound CCs. Accurately writing CCs benefits learning CCs by simplifying and speeding up the writing process (Jaganathan and Lee, 2014; Zhang, 2014). This study validates the effectiveness of static stroke-by-stroke VI with colour hints and arrows for assisting in writing SRs, which dramatically reduces the number of errors in writing SRs. The accuracy of writing SRs at the beginning of learning is essential, as it avoids forming the habit of writing inaccurately in the beginning. Moreover, as far as we know, this is the first study to test the effectiveness of static VIs for writing SRs, while previous studies (e.g., Xu et al., 2013) explored the effectiveness of animation for introducing the writing process of CCs.

Thirdly, 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 relayed heavily on self-learning of CCs and SRs. All participants were asked to learn SRs with the VIs without extra verbal explanations in this study. Thus, the findings of this study enhance the effectiveness of self-learning of SRs by non-specialist beginners, including memorising and writing SRs.

Fourthly, the findings of this study can be used to investigate usability of information and instructional design in other fields, especially focusing on the effectiveness of design. Integrated illustrations might be effective for enhancing learning knowledge in other subjects such as biology and mechanical engineering. Stroke-by-stroke VIs with colour hints and arrows might be suitable for learning and writing other language scripts, as long as stroke order and directions are essential in their writing rules. The user-centred and mixed research methods approach can be used to investigate the effectiveness of information and instructional design in other areas such as healthcare and wellbeing.

8.3 Future research

Generalising groups of learners who use VIs for learning SRs or CCs can be investigated in future research. This study investigates the VIs of learning SRs for general adult non-specialist beginners. The group of learners can be generalised in future research to other groups. First, VIs for learners at different ages (e.g., adolescent learners and child learners) can be further explored in the 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 are able to 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 of learning (in this case co-learning) 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 learning CCs. For example, colour-blind (or colour weakness) learners and learners with dyslexia. Therefore, the effectiveness of VIs for enhancing learning CCs for different groups of learners can be further explored in future research.

Expanding the number of SRs that are presented by the VIs can be explored in future research as well. This study tested the VIs with 37[19] SRs in five studies, which were suitable and a relatively large number of SRs for learning by non-specialist beginners. The effectiveness of the VIs with more Chinese SRs (a total of 201 SRs in standard CCs) can be further explored with specialist beginners, intermediate and advanced learners. Moreover, this study only selected and tested the SRs with four different positions (left, right, top and bottom), which are common positions for SRs in CCs. The VIs explored in this study seem to be suitable for the other two positions of SRs (outside and inside), but this would need to be further explored.

Developing VIs for learning Chinese PRs (Phonetic Radicals) and traditional CCs can be investigated in future research. Apart from SRs, there are about 800 PRs in compound CCs. The VIs for enhancing learning PRs, especially the pronunciations, can be also explored. Moreover, this study explored the VIs with simplified CCs and SRs (used in mainland China). The applications of VIs in traditional CCs (used in Hong Kong, Taiwan, Japan and Korea) would need to be explored as well.

[19] For Reading & Memorising SRs, Study 1 tested six SRs, Study 2 tested 20 SRs, Study 3 tested 20 SRs. For writing SRs, Study 4 tested 15 SRs. For Reading & Memorising and writing SRs, Study 5 tested 21 SRs. Twenty-two SRs were repetitively used in different studies, there were 37 SRs were tested in total in the five studies.

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Appendices

Appendix I. A List of common SRs and related origins of CCs

(Discover China, 2020)

No.	SR	Origin CC	Meaning	Category origination
1	亻	人	People	Pictograms
2	力	力	Power	Pictograms
3	冫	冰	Ice	Compound ideograms
4	刂	刀	Knife	Pictograms
5	讠	言	Speech	Simple ideograms
6	阝 -right	邑	City	Compound ideograms
7	阝 -left	阜	Dam	Pictograms
8	冖	幂	Cover	Semantic-Phonetic-Compound CC
9	女	女	Female	Pictograms
10	彳	亍	Slow walk	Pictograms
11	口	口	Mouth	Pictograms
12	艹	草	Grass	Semantic-Phonetic-Compound CC
13	纟	糸	Silk	Pictograms
14	宀	宀	Roof	Pictograms
15	门	门	Gate	Pictograms
16	辶	辵	Walk	Compound ideograms
17	子	子	Child	Pictograms

No.	SR	Origin CC	Meaning	Category origination
18	工	工	Work	Pictograms
19	囗	回	Enclosure	Pictograms
20	弓	弓	Bow	Pictograms
21	小	小	Small	Pictograms
22	广	廣	House	Semantic-Phonetic-Compound CC
23	大	大	Big	Pictograms
24	土	土	Soil	Pictograms
25	彡	彡	Picture	Pictograms
26	夕	夕	Sunset	Simple ideograms
27	山	山	Mountain	Pictograms
28	巾	巾	Scarf	Pictograms
29	饣	食	Food	Compound ideograms
30	忄	心	Heart	Pictograms
31	氵	水	Water	Pictograms
32	犭	犬	Animal	Pictograms
33	扌	手	Hand	Pictograms
34	马	马	Horse	Pictograms
35	心	心	Heart	Pictograms
36	木	木	Wood	Pictograms
37	贝	贝	Money	Pictograms

No.	SR	Origin CC	Meaning	Category origination
38	月	月	Moon	Pictograms
39	日	日	Sun	Pictograms
40	王	王	King	Pictograms
41	火	火	Fire	Pictograms
42	攵	攴	Knock	Semantic-Phonetic-Compound CC
43	犬	犬	Animal	Pictograms
44	户	户	House	Pictograms
45	爫	爪	Claw	Pictograms
46	手	扌	Hand	Pictograms
47	牛	牛	Ox	Pictograms
48	欠	欠	Open mouth	Pictograms
49	车	车	Vehicle	Pictograms
50	方	方	Flag	Pictograms
51	片	片	Piece	Simple ideograms
52	礻	示	Sign	Compound ideograms
53	父	父	Male adult	Simple ideograms
54	斤	斤	Axe	Pictograms
55	田	田	Field	Pictograms
56	白	白	White	Pictograms
57	禾	禾	Grain	Pictograms
58	石	石	Stone	Pictograms

No.	SR	Origin CC	Meaning	Category origination
59	示	示	Sign	Compound ideograms
60	鸟	鸟	Bird	Pictograms
61	目	目	Eye	Pictograms
62	立	立	Stand	Compound ideograms
63	衤	衣	Clothes	Pictograms
64	钅	金	Metal	Compound ideograms
65	玉	玉	Jade	Pictograms
66	疒	倚	Illness	Pictograms
67	穴	穴	Cave	Pictograms
68	虍	虎	Tiger	Pictograms
69	覀	要	Cover	Pictograms
70	羊	羊	Sheep	Pictograms
71	⺮	竹	Bamboo	Pictograms
72	自	自	Nose	Pictograms
73	耳	耳	Ear	Pictograms
74	衣	衣	Clothes	Pictograms
75	舟	舟	Boat	Pictograms
76	米	米	Rice	Pictograms
77	页	页	Neck	Pictograms
78	糸	糸	Silk	Pictograms
79	虫	虫	Insect	Compound ideograms

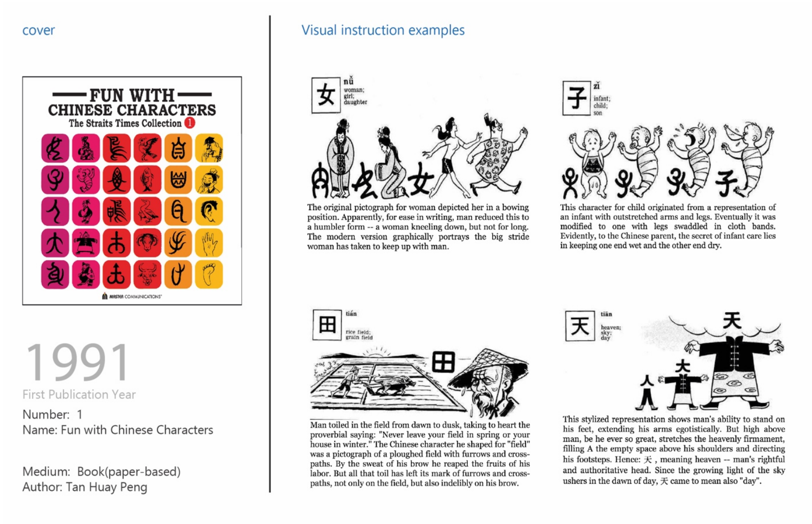
No.	SR	Origin CC	Meaning	Category origination
80	言	言	Speak	Simple ideograms
81	⻊	足	Foot	Compound ideograms
82	走	走	Walk	Compound ideograms
83	酉	酉	Alcohol	Pictograms
84	身	身	Body	Pictograms
85	豸	豸	Beast	Pictograms
86	鱼	鱼	Fish	Pictograms
87	雨	雨	Rain	Pictograms
88	金	金	Metal	Compound ideograms
89	革	革	Leather	Pictograms
90	食	食	Eat	Compound ideograms
91	鬼	鬼	Ghost	Pictograms
92	音	音	Sound	Simple ideograms

Pictograms	71
Semantic-Phonetic-Compound CC	4
Simple ideograms	5
Compound ideograms	12

Appendix II. A List of existing cases

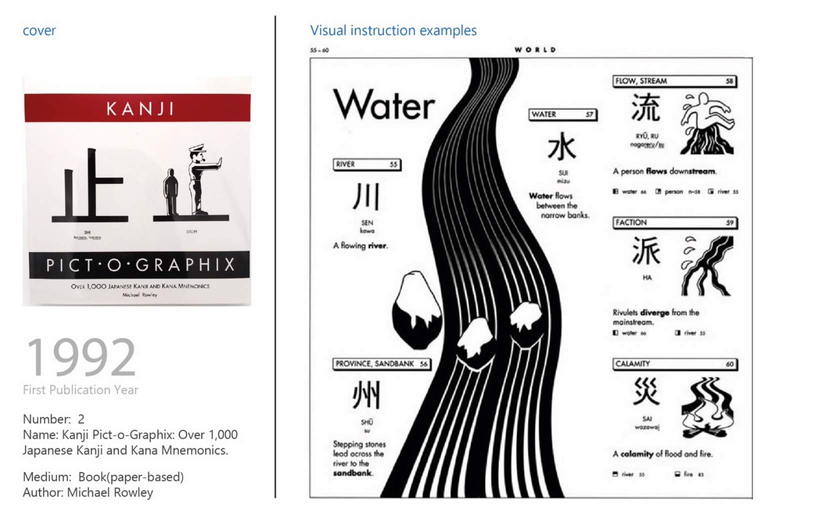
No. 1

- Case: Fun with Chinese Characters (Peng, 2012).
- The first publish/release year: 1991
- Medium: Book
- Authors/ Providers: Tan Huay Peng / Master Communications, Inc.



No. 2

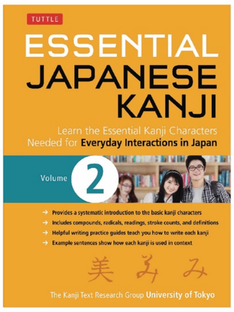
- Kanji Pict-o-Graphix: Over 1,000 Japanese Kanji and Kana Mnemonics (Rowley, 1992).
- 1992
- Book
- Michael Rowley / Stone Bridge Press



- Essential Japanese Kanji (University of Tokyo Kanji Research Group, 2015).
- 1993
- Book
- University of Tokyo Kanji Research Group / Tuttle Publishing

No. 3

cover



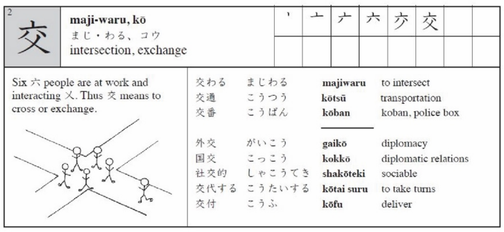
1993

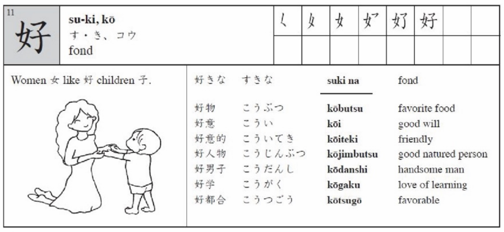
First Publication Year

Number: 3
Name: Essential Japanese Kanji

Medium: Book(paper-based)
Authors: University of Tokyo
Kanji Reseach Group

Visual instruction examples

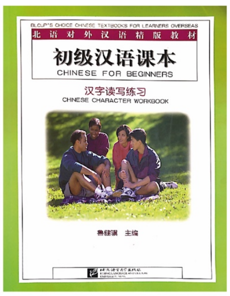




- Chinese for beginners-Chinese characters workbook-BLCUP's Choice Chinese textbooks for learners overseas
- 2002
- Book
- Jianji Lu / Beijing Language and Culture University Press

No. 4

cover



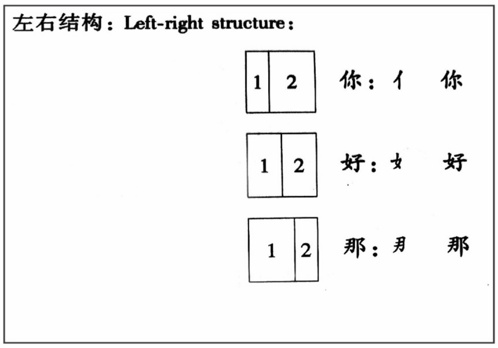
2002

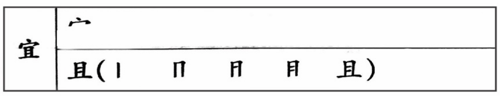
First Publication Year

Number: 4
Name: Chinese for beginners-Chinese characters workbook-BLCUP's Choice Chinese textbooks for learners overseas

Medium: Book(paper-based)
Editor-in-chief: Lu Jianji

Visual instruction examples



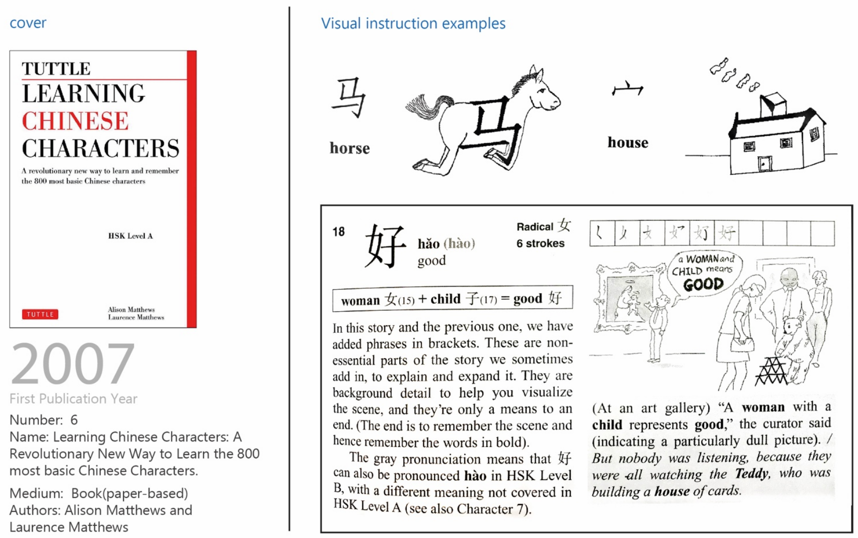


- Zhi Ying Chinese Characters Recognition (Zhang, X.Q.张秀琴, 2014)
- 2014
- Book
- Xiuqin Zhang / Hangzhou chu ban she

No. 5

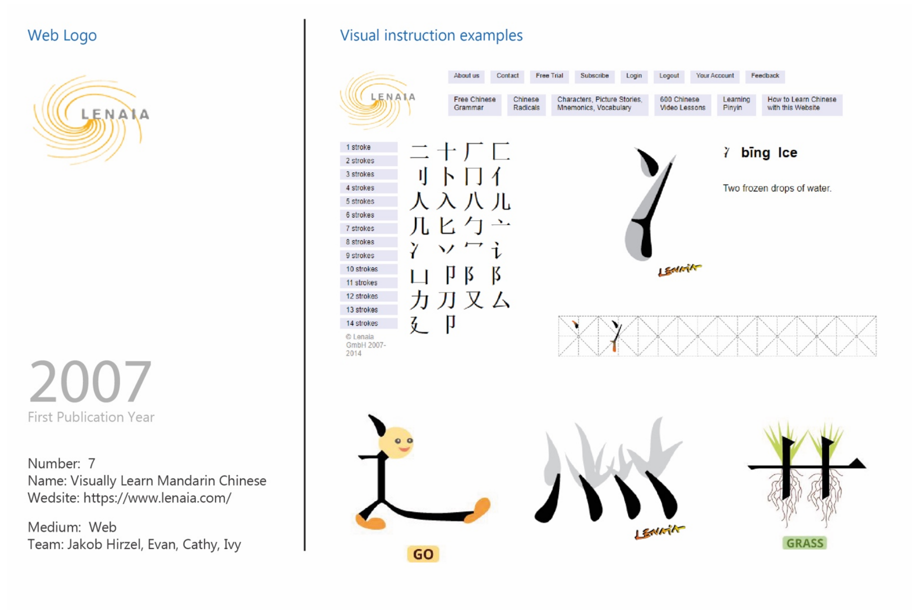
- Learning Chinese Characters: A Revolutionary New Way to Learn the 800 most basic Chinese Characters (Matthews and Matthews, 2007).
- 2007
- Book
- Matthews, A. and Matthews, L. / Tuttle Publishing

No. 6



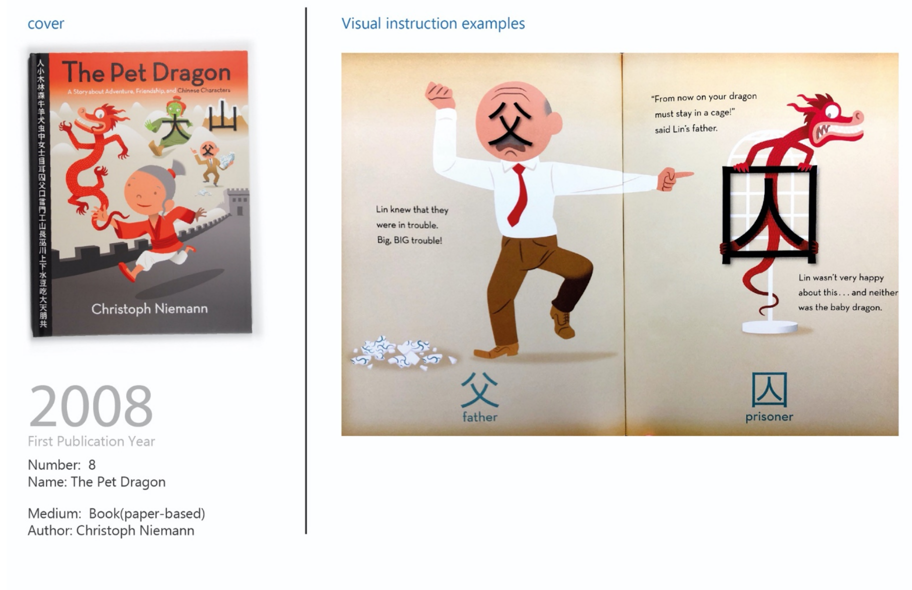
- Lenaia-Visually Learn Mandarin Chinese https://www.lenaia.com/ (Hirzel et al., 2007).
- 2007
- Website
- Jakob Hirzel, Evan, Cathy, Ivy

No. 7



- The Pet Dragon (Niemann, 2008)
- 2008
- Book
- Christoph Niemann / HarperCollins

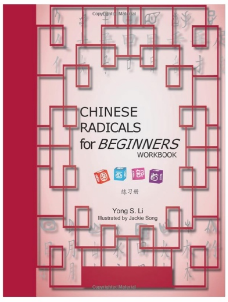
No. 8



- Chinese Radicals for Beginners (Li and Song, 2008).
- 2008
- Book
- Yong S. Li, Jackie Song / CreateSpace Independent Publishing Platform

No. 9

cover

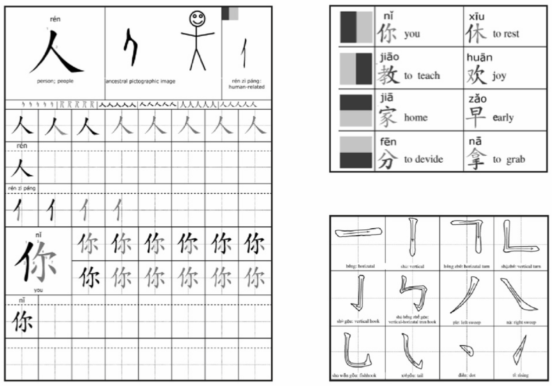


2008
First Publication Year

Number: 9
Name: The Pet Dragon

Medium: Book(paper-based)
Author: Yong S. Li, Jackie Song

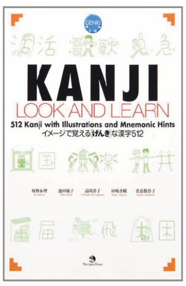
Visual instruction examples



- Kanji, Look and Learn- 512 Kanji with illustrations and Mnemonic Hints (Banno et al., 2009).
- 2009
- Book
- Banno Eri, Yoko Ikeda, Chikako Shinagawa, Kyoko Tokashiki, Kaori Tajima / The Japan Times

No. 10

cover

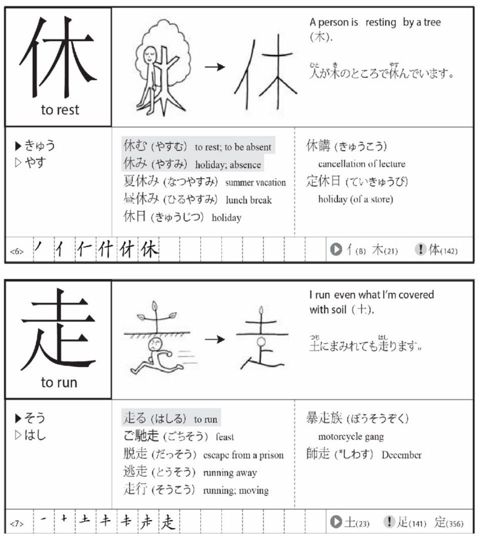


2008
First Publication Year

Number: 10
Name: Kanji, Look and Learn- 512 Kanji with illustrations and Mnemonic Hints.

Medium: Book(paper-based)
Author: Banno Eri, Yoko Ikeda, Chikako Shinagawa, Kyoko Tokashiki, Kaori Tajima

Visual instruction examples

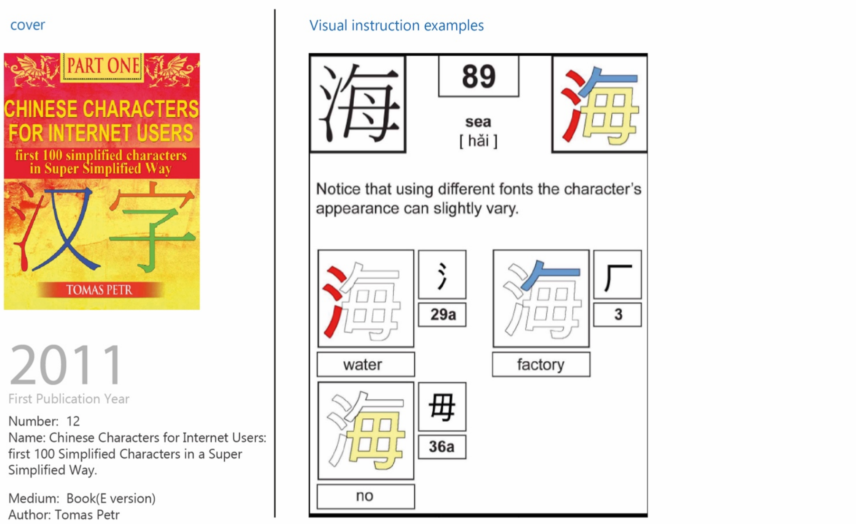


- Discover China (Anqi et al., 2010).
- 2010
- Book
- Ding Anqi, Lily Jing, Xin Chen / Macmillan Education

No. 11

- Chinese Characters for Internet Users: first 100 Simplified Characters in a Super Simplified Way (Peter, 2013).
- 2011
- Book
- Petr, Tomas / iScribio! Foreign Language Learning Apps

No. 12

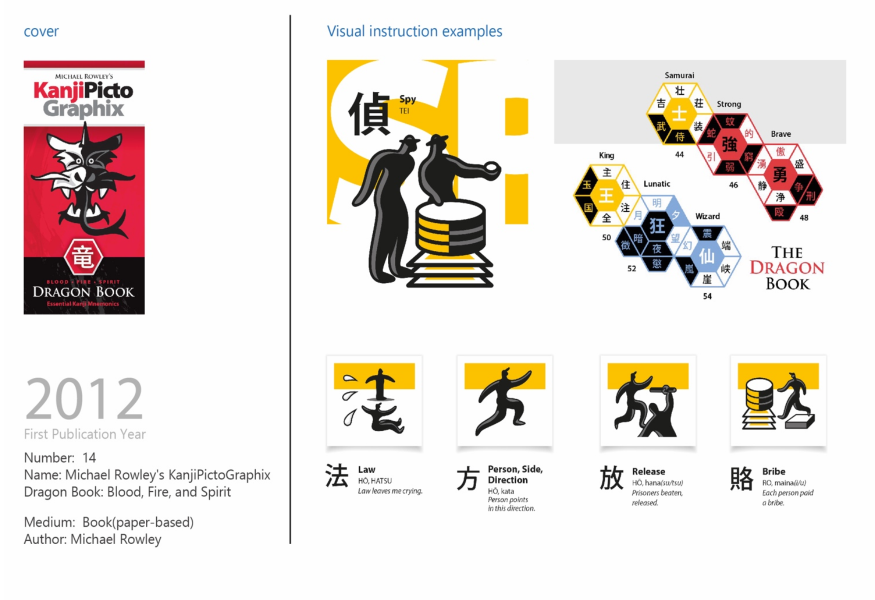


- Art of Chinese Characters (Taiwan Knowledge Bank Co. Ltd, 2012).
- 2012
- App
- Taiwan Knowledge Bank Co., Ltd.

No. 13

- Kanji PictoGraphix Dragon Book: Blood, Fire, and Spirit (Rowley, 2012).
- 2012
- Book
- Michael Rowley / Stone Bridge Press

No. 14



- Kanji Learn Japanese Writing Middle school Textbook Workbook (Gakken, 2012).
- 2012
- Book
- Gakken

No. 15

cover

2012
First Publication Year

Number: 15
Name: Kanji Learn Japanese Writing Middle school Textbook Workbook

Medium: Book(paper-based)
Publication: Gakken

Visual instruction examples

- Ninchanese https://ninchanese.com/ (Ninchanese Team, 2013).
- 2013
- Website
- Ninchanese Team

No. 16

Web Logo

Ninchanese

2013
First release Year

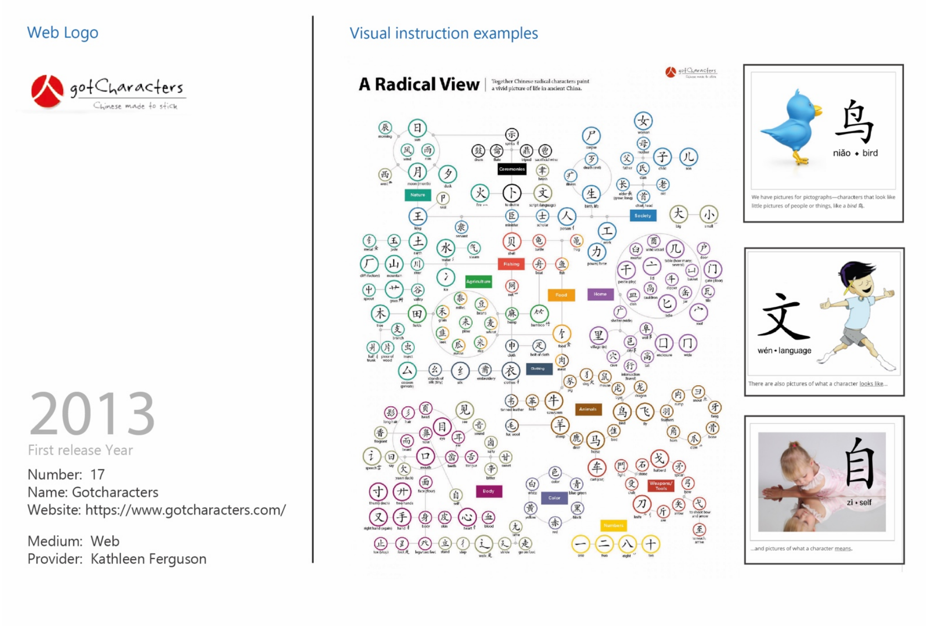
Number: 16
Name: Ninchanese
Website: https://ninchanese.com/

Medium: Web
Provider: Ninchanese Team

Visual instruction examples

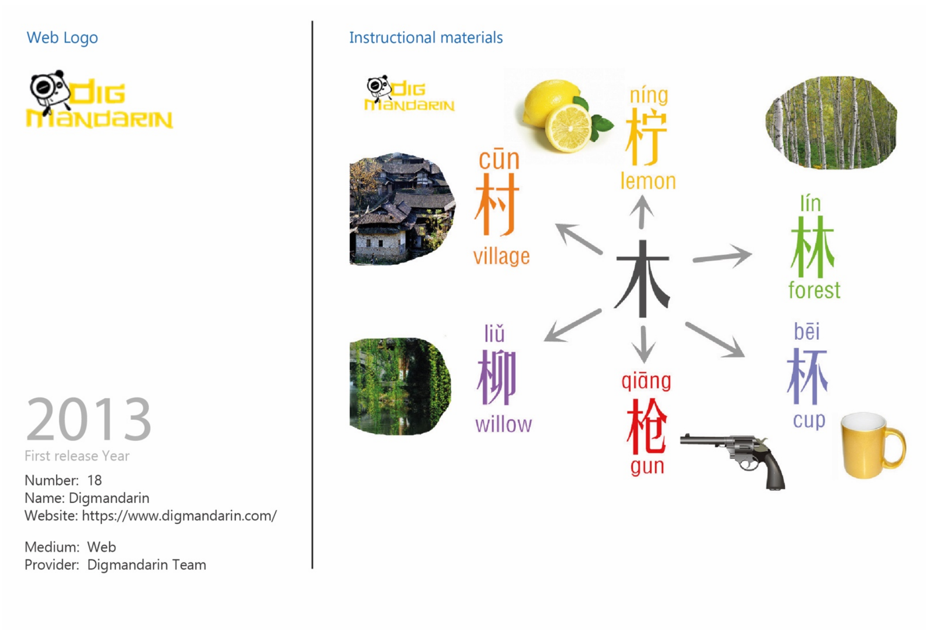
- Gotcharacters https://www.gotcharacters.com/ (Ferguson, 2013).
- 2013
- Website
- Kathleen Ferguson

No. 17



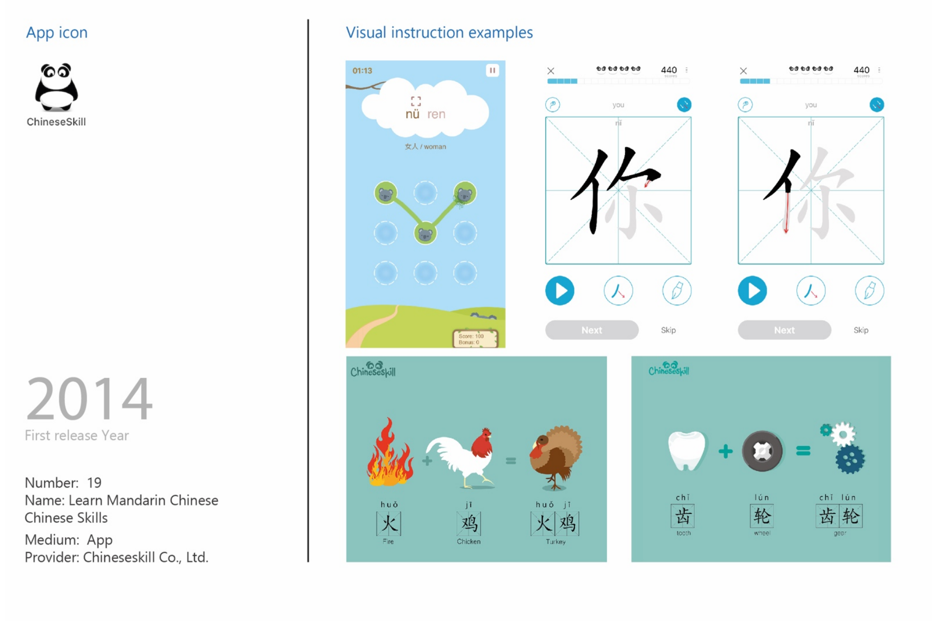
- Digmandarin https://www.digmandarin.com/ (Digmandarin Team, 2013).
- 2013
- Website
- Digmandarin Team

No. 18



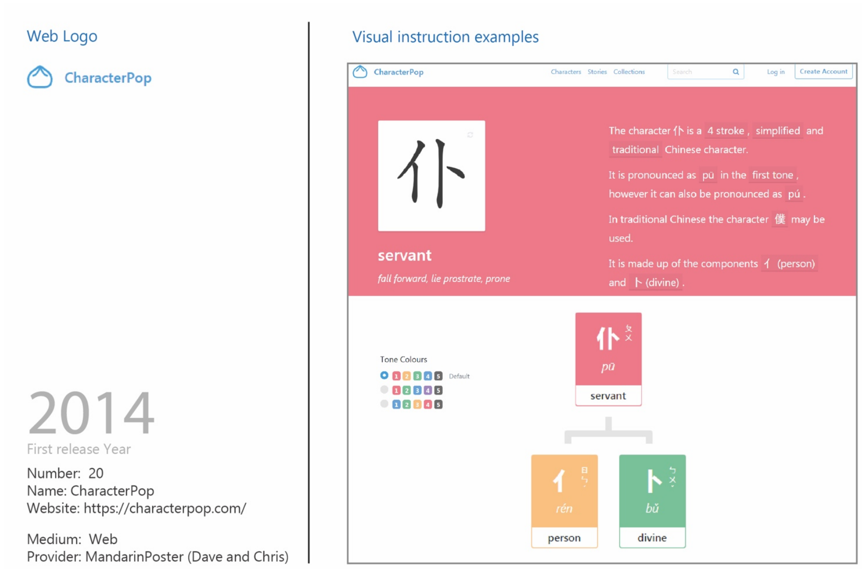
- Chinese Skills -Learn Chinese) (ChineseSkill Co. Ltd, 2014).
- 2014
- App
- Chineseskill Co., Ltd.

No. 19



- CharacterPop https://characterpop.com/ (Dave, 2014)
- 2014
- Website
- MandarinPoster (Dave and Chris)

No. 20

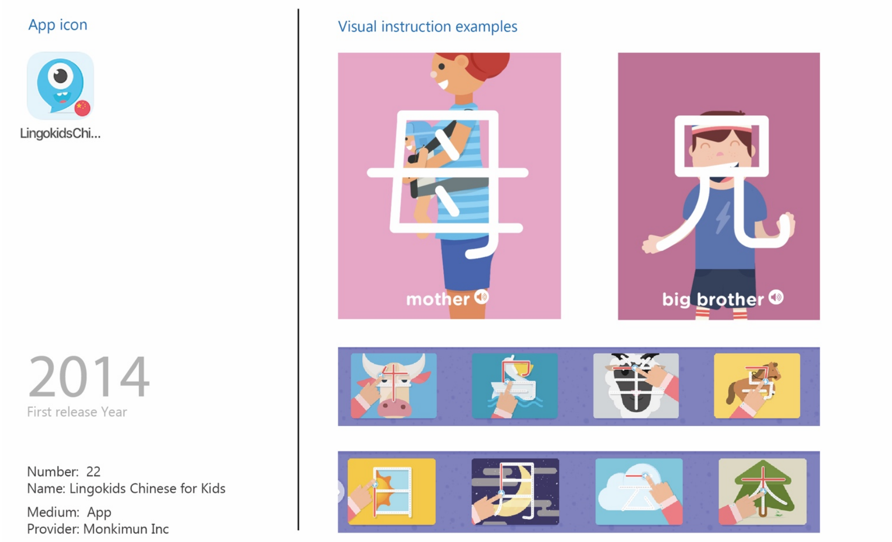


- Hiragana Katakana Kanji Textbook Japanese Book School Workbook Language Basic (Daiso, 2014).
- 2014
- Book
- Daiso-shuppan

No. 21

- Chinese for children Lingokids (Monkimun Team, 2014).
- 2014
- App
- Monkimun Inc

No. 22



- Fun and Easy Chinese (Greenwood, 2014).
- 2014
- Book
- Elinor Greenwood / Noodle Publishing

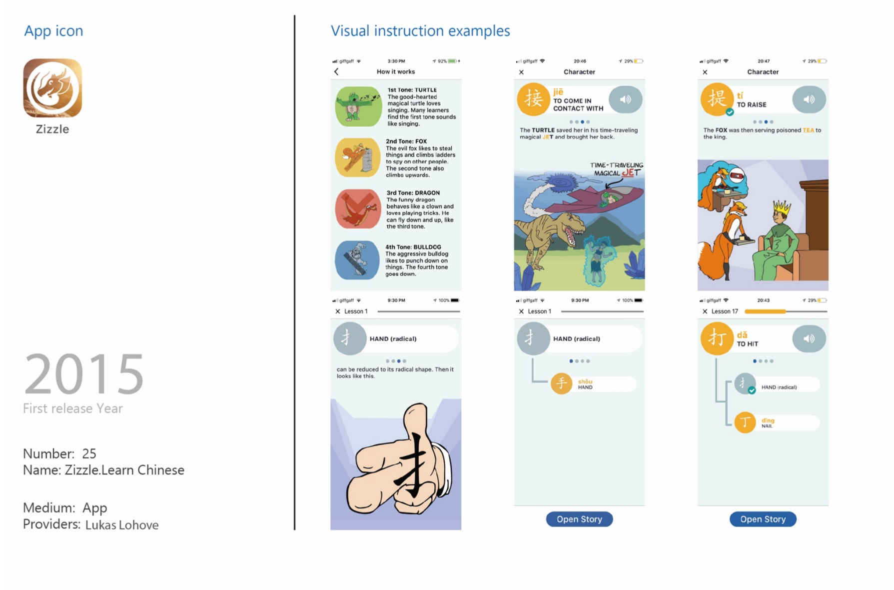
No. 23

- Chineasy: The New Way to Read Chinese (Hsueh, 2014).
- 2014
- Book
- ShaoLan, Hue / Thames & Hudson

No. 24

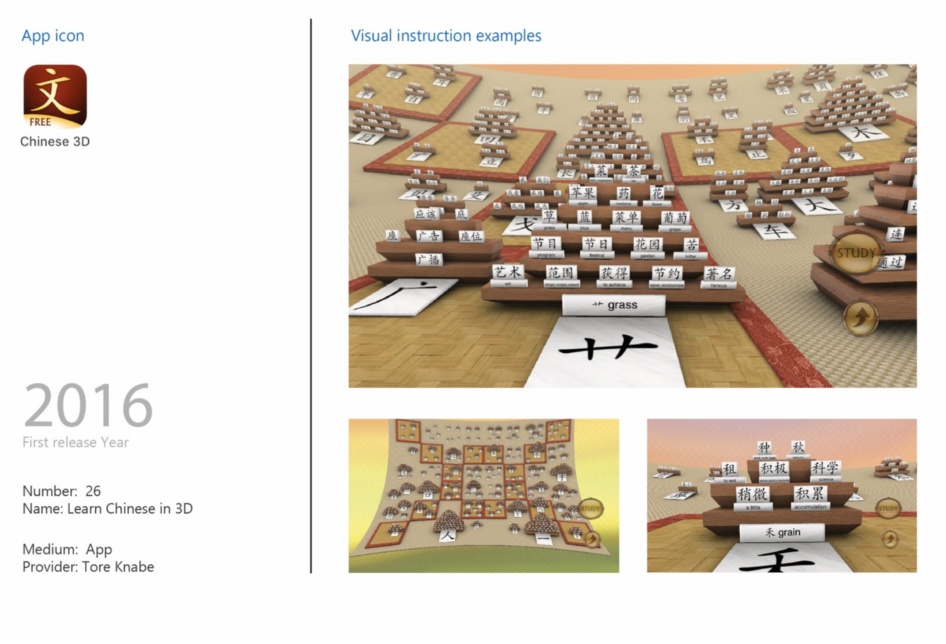
- Learn Chinese with Zizzle (Lohove, 2015).
- 2015
- App
- Lukas, Kevin, Hagen, Alexandra

No. 25



- Learn Chinese in 3D (Knabe, 2013).
- 2016
- App
- Tore Knabe

No. 26

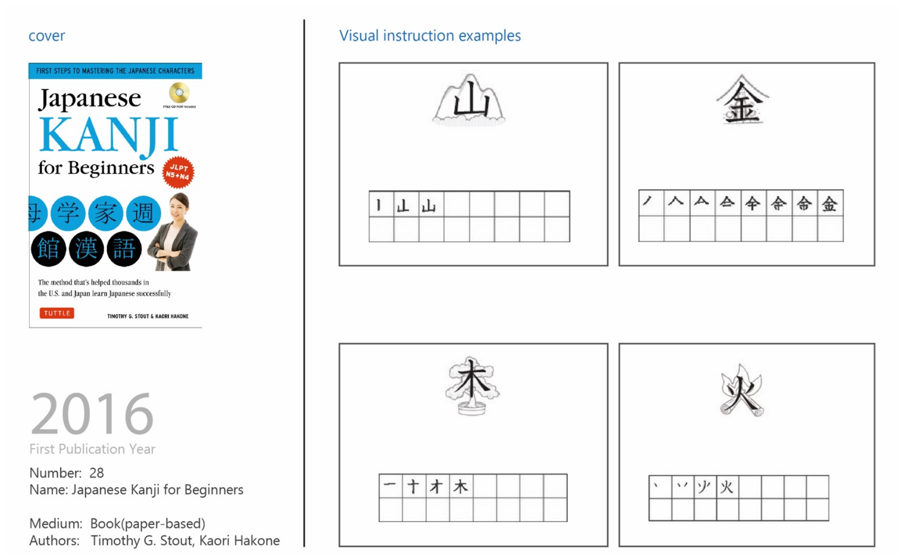


- Chineasy Everyday: The world of Chinese Characters (Hsueh, 2016)
- 2016
- Book
- ShaoLan, Hue / Thames & Hudson

No. 27

- Japanese Kanji for Beginners (Stout and Hakone, 2016).
- 2016
- Book
- Timothy G. Stout, Kaori Hakone / Tuttle Publishing

No. 28

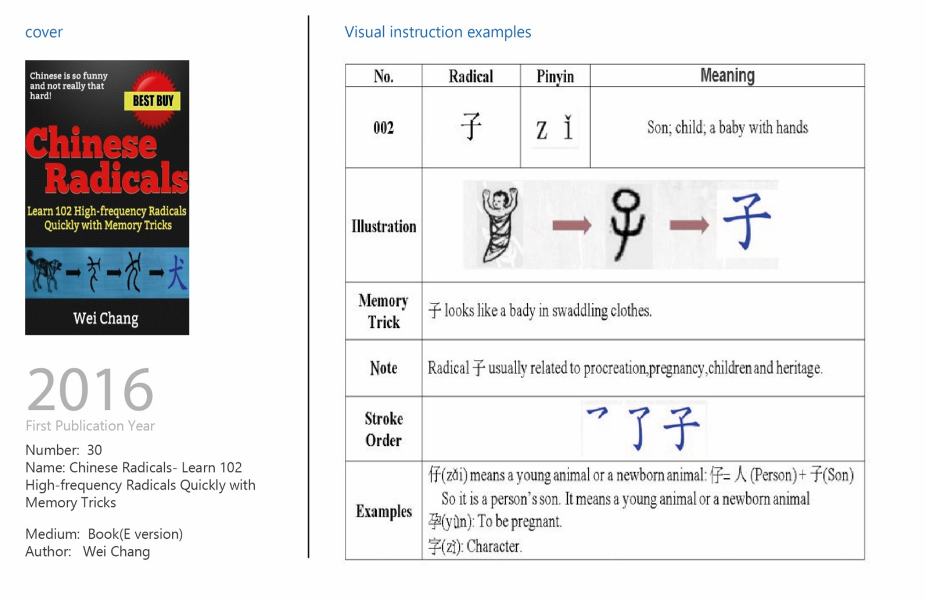


- My very first book of Chinese Characters (XiaoXiang Hanzi, 2016).
- 2016
- Book
- XiaoXiang Hanzi Team / Fudan University Press

No. 29

- Chinese Radicals: Learn 102 High-frequency Radicals Quickly with Memory Tricks (Chang, 2016).
- 2016
- Book
- Wei Chang / Amazon Kindle

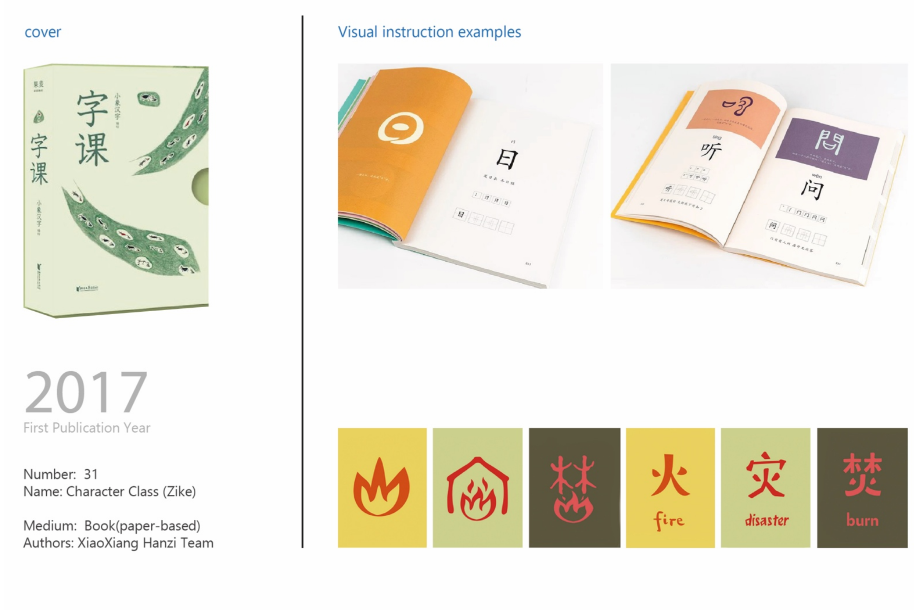
No. 30



No.	Radical	Pinyin	Meaning
002	子	z ǐ	Son; child; a baby with hands
Illustration			
Memory Trick	子 looks like a bady in swaddling clothes.		
Note	Radical 子 usually related to procreation,pregnancy,children and heritage.		
Stroke Order			
Examples	仔(zǎi) means a young animal or a newborn animal: 仔= 人 (Person)+ 子(Son) So it is a person's son. It means a young animal or a newborn animal 孕(yùn): To be pregnant. 字(zì): Character.		

- ZiKe (XiaoXiang Hanzi, 2017b).
- 2017
- Book
- XiaoXiang Hanzi Team / Zhejiang Literature and Art Publishing House

No. 31



- Like Pictures, Like Chinese (XiaoXiang Hanzi, 2017a).
- 2017
- Book
- Xiaoxiang Hanzi Team / Zhejiang Literature and Art Publishing House

No. 32

- Poop Themed Kanji Study Workbook (文響社, 2017).
- 2017
- Book
- Bunkyosha

No. 33

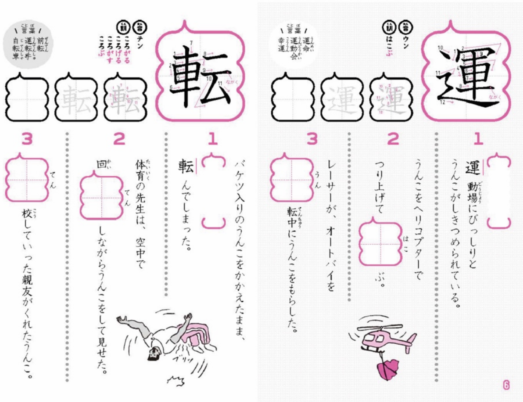
cover

2017
First Publication Year

Number: 33
Name: Poop Themed Kanji Study Workbook

Medium: Book(paper-based)
Author: Bunkyosha

Visual instruction examples



- Your First Hanja Guide (Kong & Park, 2018).
- 2018
- Book
- Kong & Park

No. 34

cover

2018
First Publication Year

Number: 34
Name: Your First Hanja Guide

Medium: Book(paper-based)
Authors: Talk to me in Koren, Kong & Park

Visual instruction examples

- Kanji 1026 cards learned by Japanese elementary school students (Gakken, 2018).
- 2018
- Book
- Gakken / The Japan Times

No. 35

cover

2018

First Publication Year

Number: 35

Name: Kanji 1026 cards learned by Japanese elementary school students

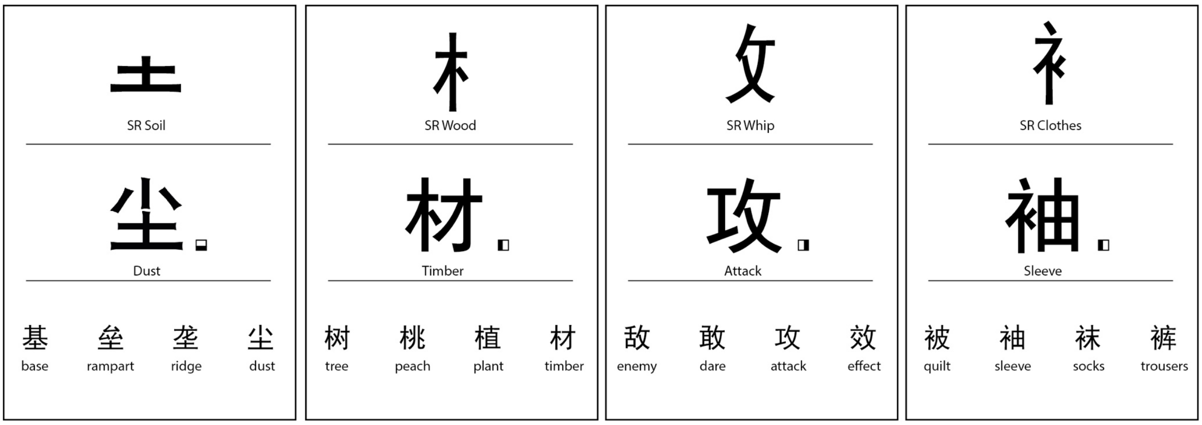
Medium: Book(paper-based)

Publication: The Japan Times

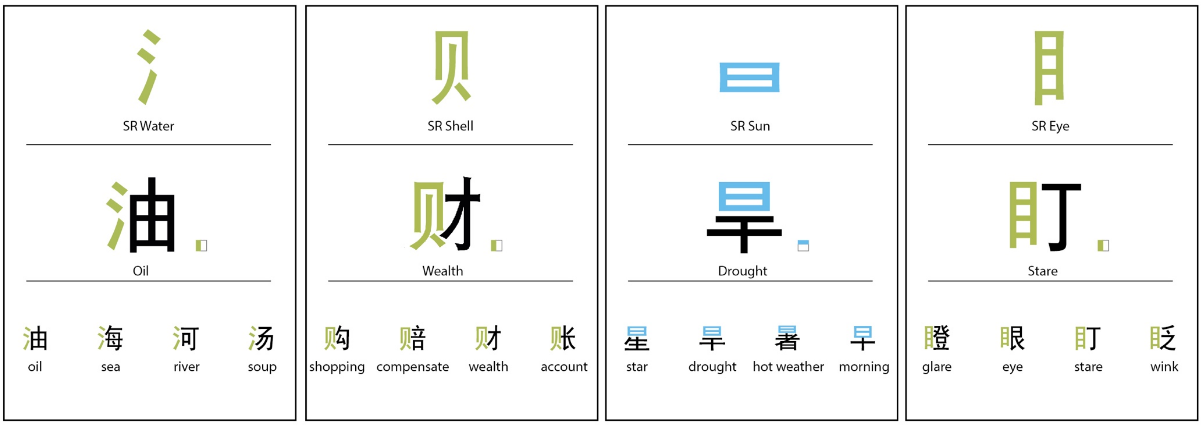
Visual instruction examples

Appendix III. Samples A1, A2, A3, A4, A5

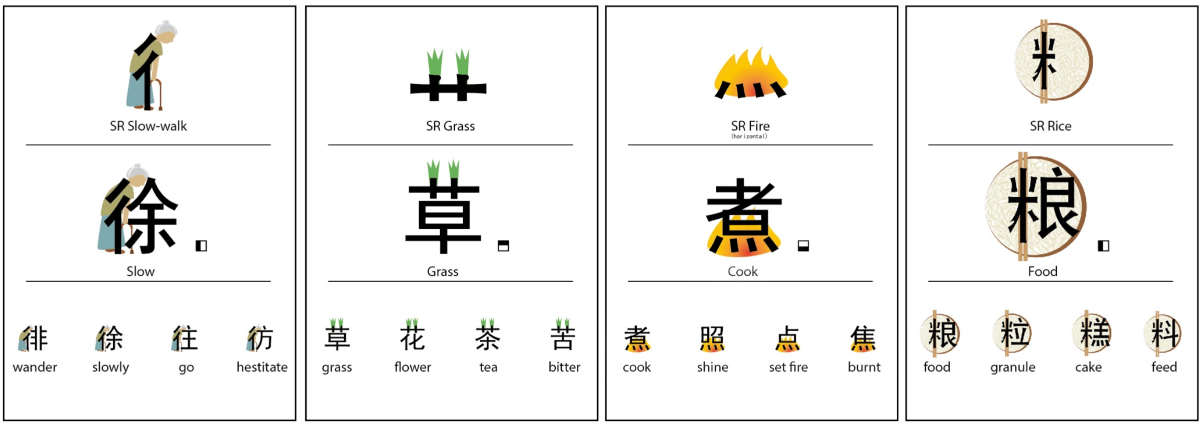
Sample A1



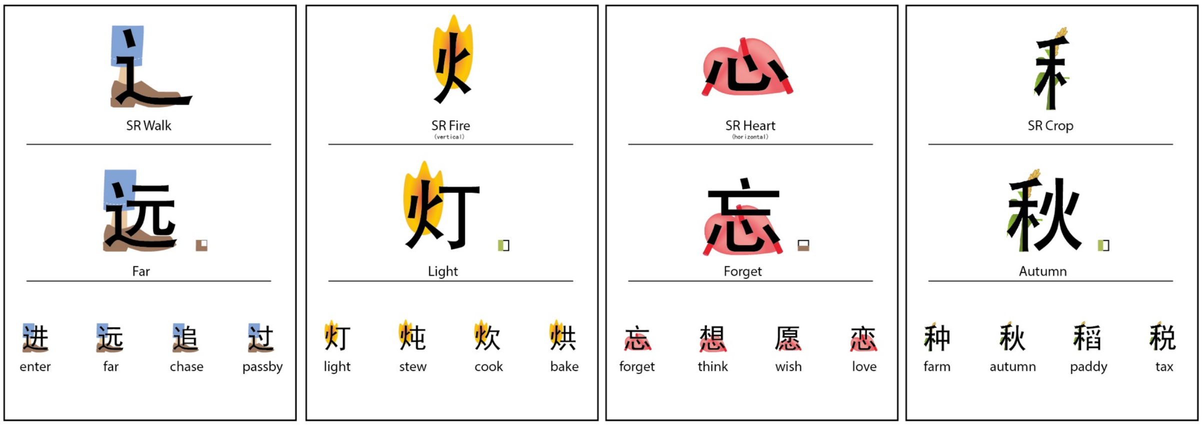
Sample A2



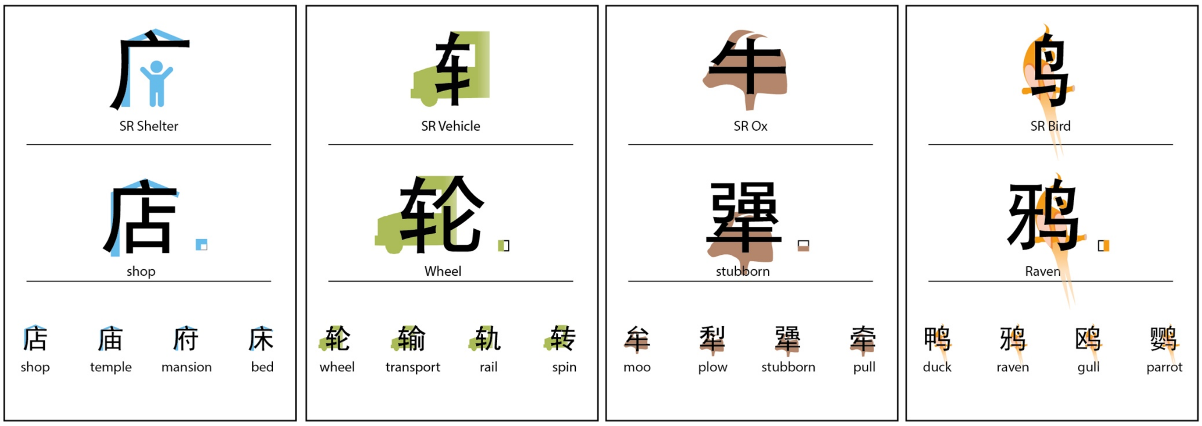
Sample A3



Sample A4

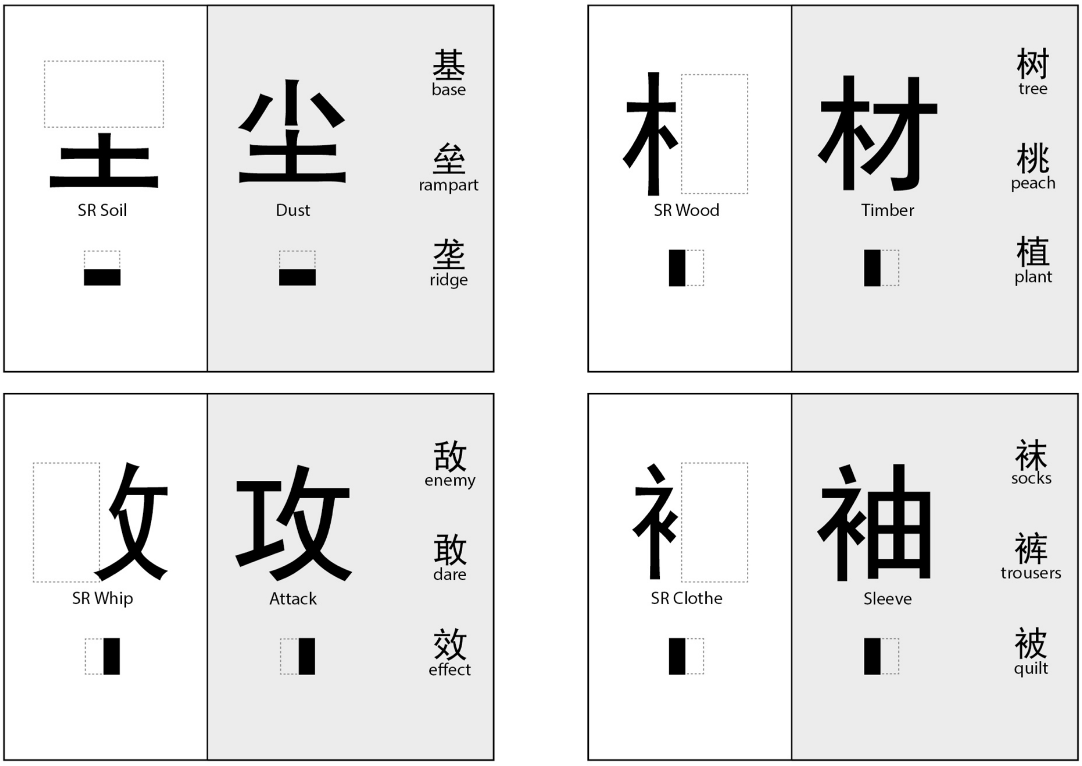


Sample A5

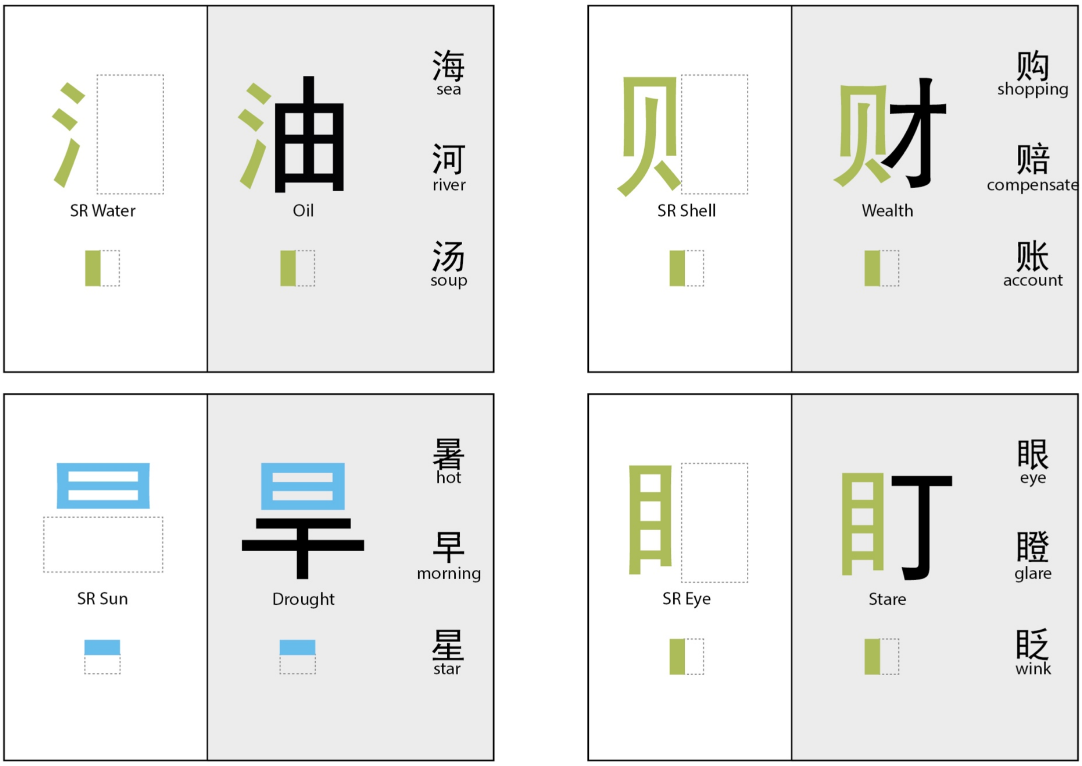


Appendix IV. Samples B1, B2, B3, B4, B5

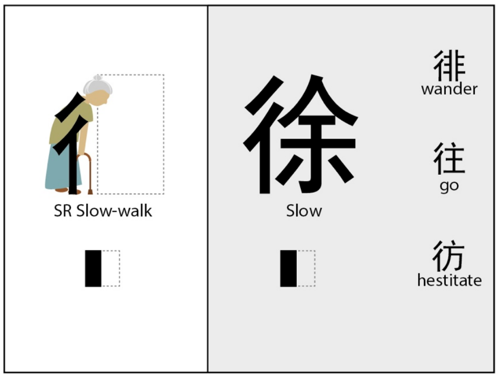
Sample B1

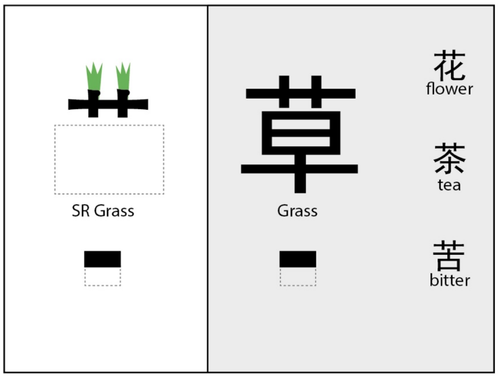


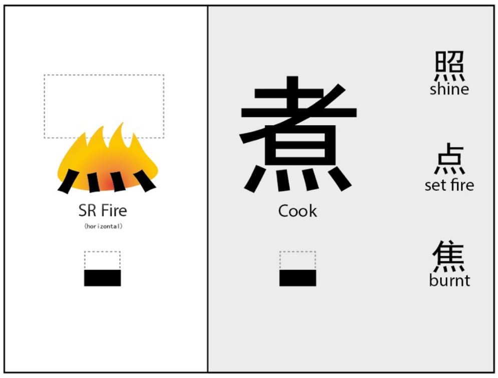
Sample B2

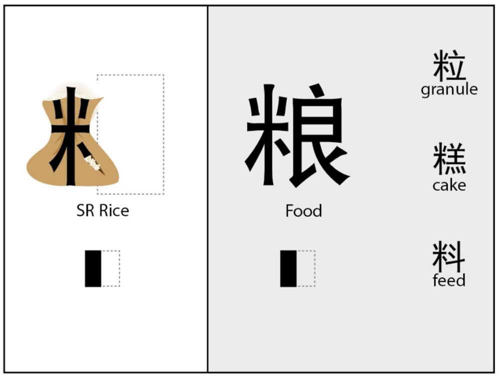


Sample B3

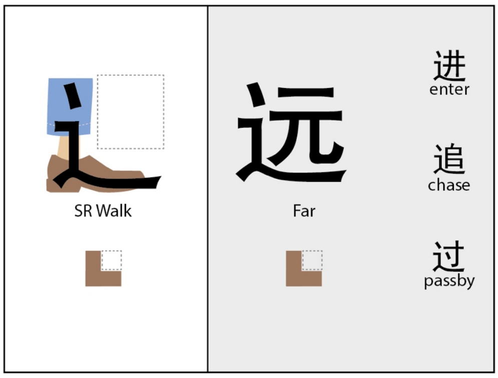


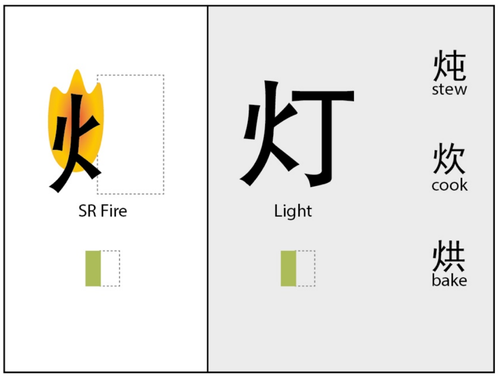


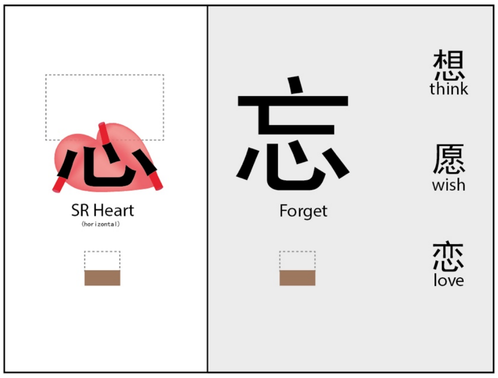


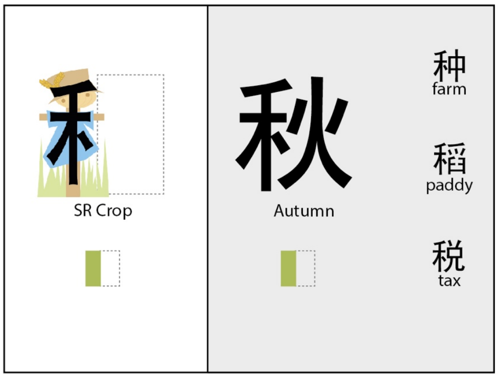


Sample B4

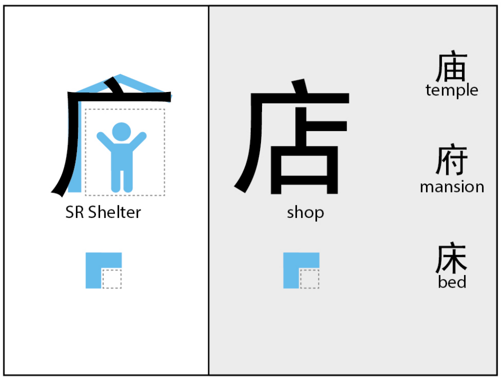


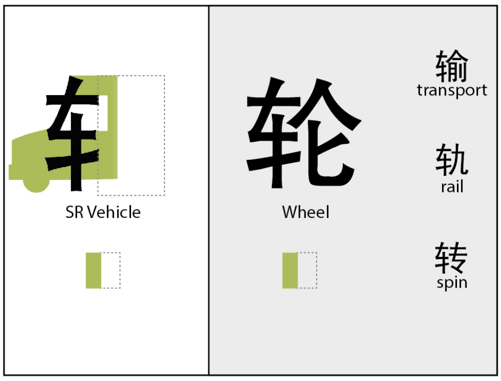


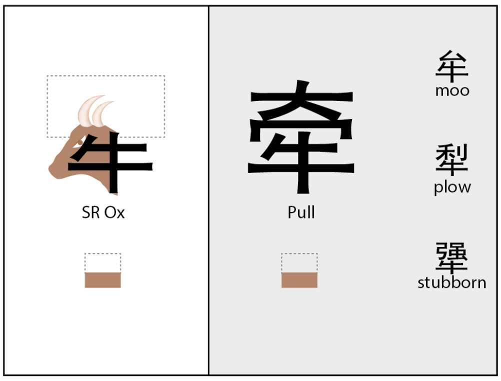


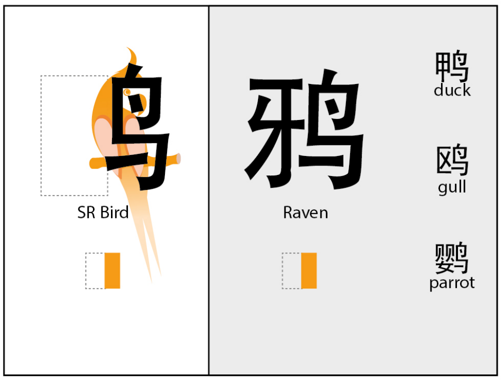


Sample B5


广
SR Shelter
店
shop
庙
temple
府
mansion
床
bed

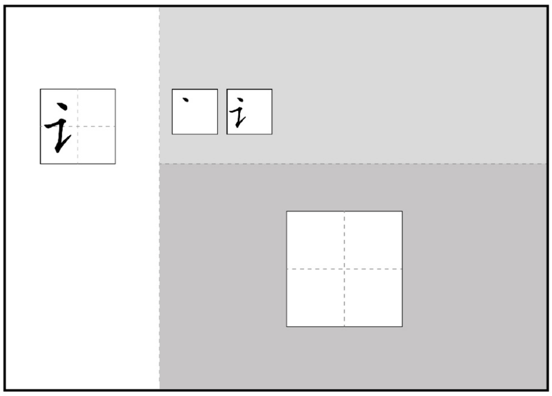

车
SR Vehicle
轮
Wheel
输
transport
轨
rail
转
spin


牛
SR Ox
牵
Pull
牟
moo
犁
plow
犟
stubborn

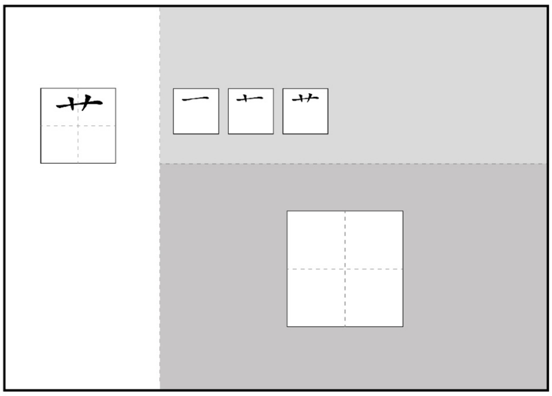

鸟
SR Bird
鸦
Raven
鸭
duck
鸥
gull
鹦
parrot

Appendix V. Samples C1, C2, C3

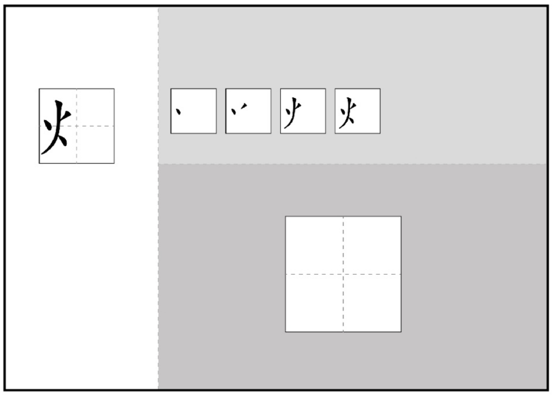
Sample C1



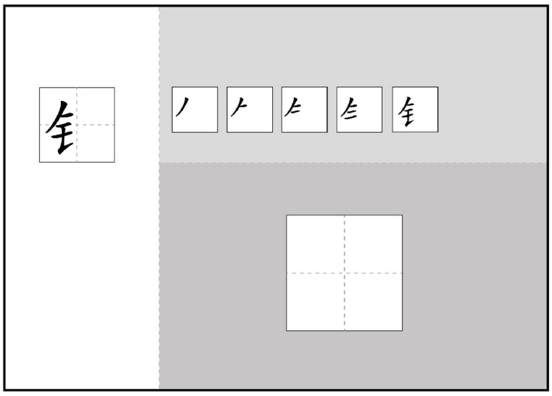
C1SR1
Stroke Number: 2



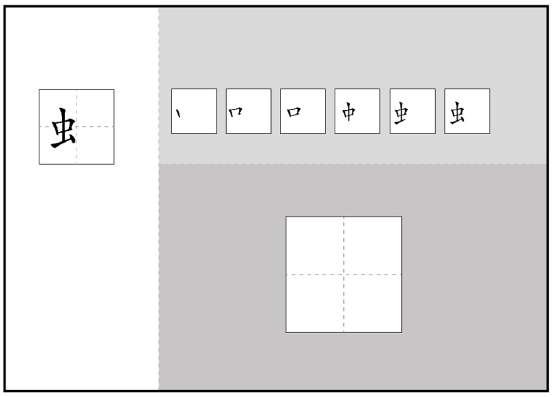
C1SR2
Stroke Number: 3



C1SR3
Stroke Number: 4

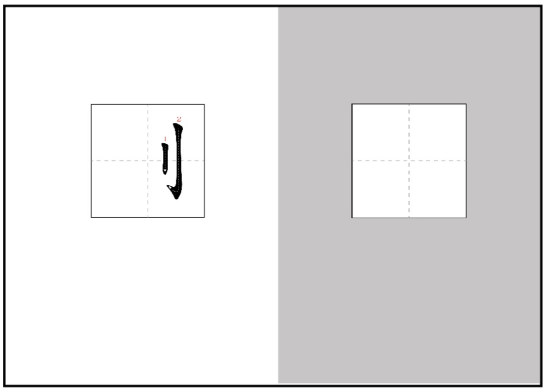


C1SR4
Stroke Number: 5

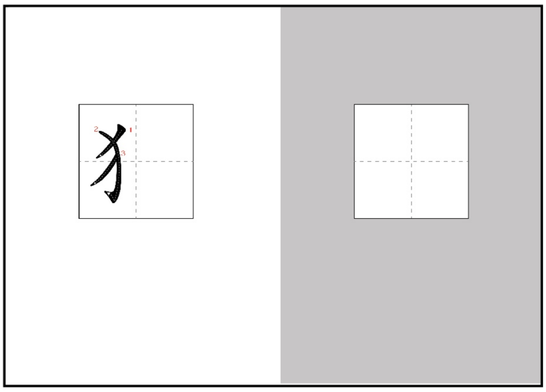


C1SR5
Stroke Number: 6

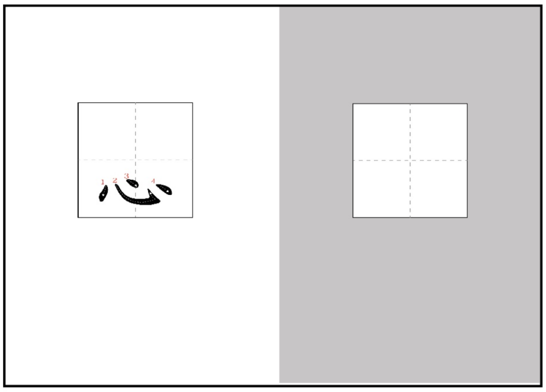
Sample C2



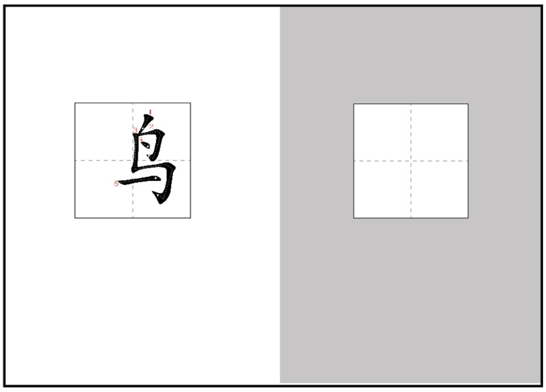
C2SR1
Stroke Number: 2



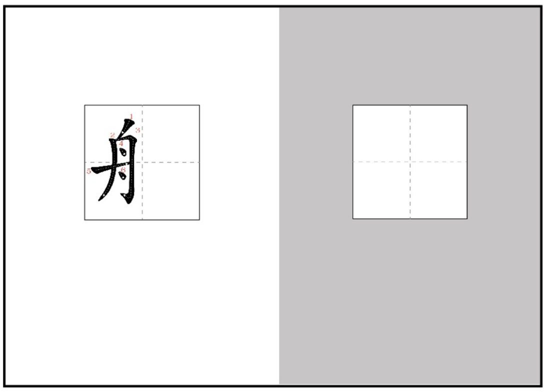
C2SR2
Stroke Number: 3



C2SR3
Stroke Number: 4

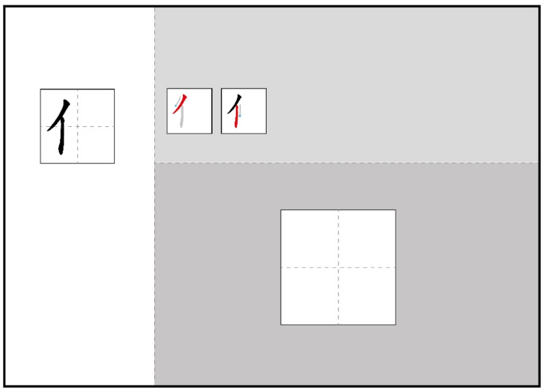


C2SR4
Stroke Number: 5

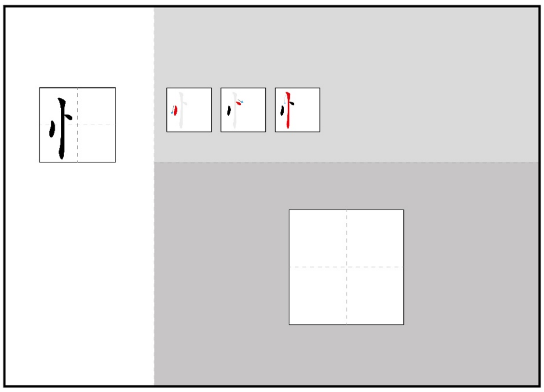


C2SR5
Stroke Number: 6

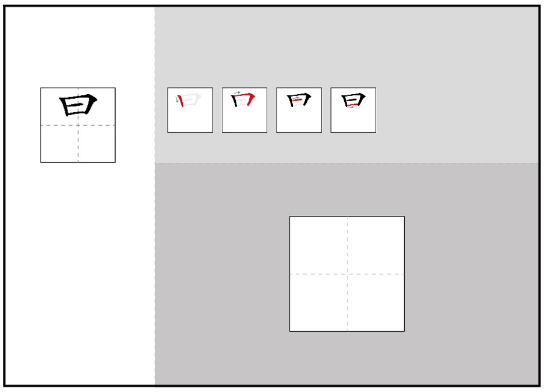
Sample C3



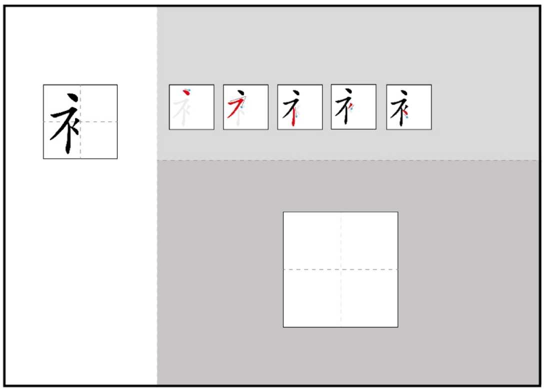
C3SR1
Stroke Number: 2



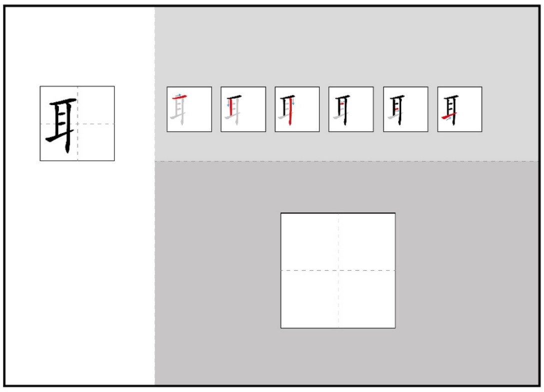
C3SR2
Stroke Number: 3



C3SR3
Stroke Number: 4



C3SR4
Stroke Number: 5



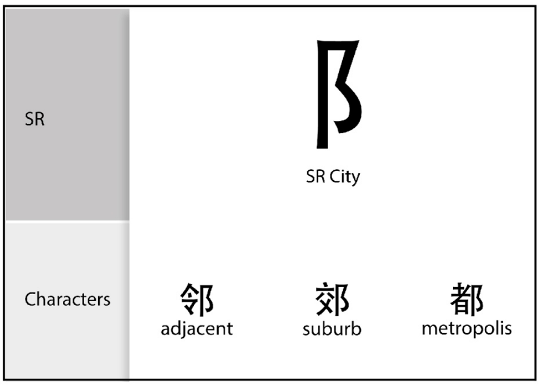
C3SR5
Stroke Number: 6

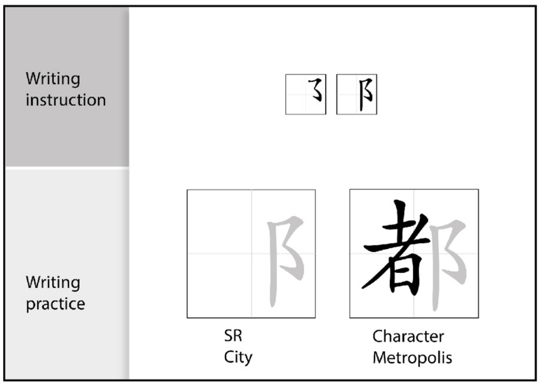
Appendix VI. Samples D1, D2, D3

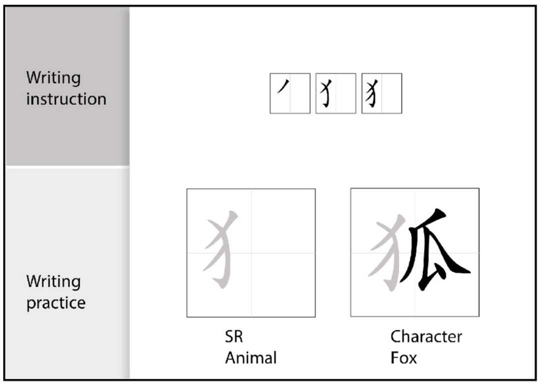
SR Group 1

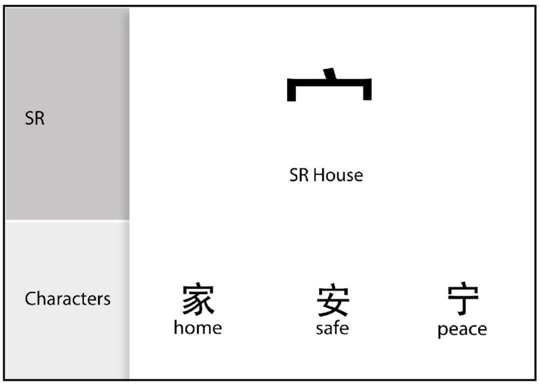
阝	犭	宀	牛	日	禾	米
City	Animal	House	Ox	Sun	Crop	Rice

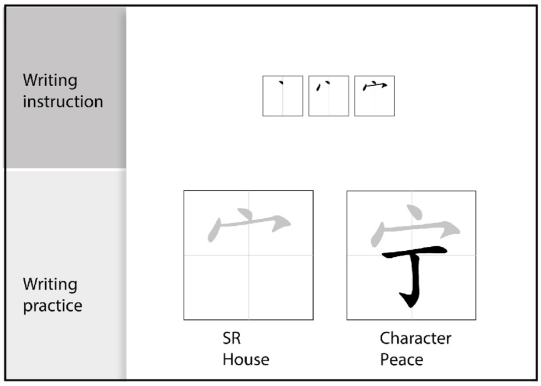
Sample D1







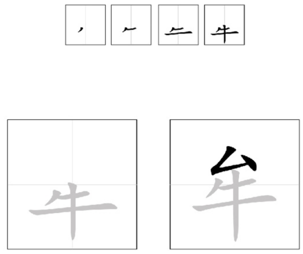




SR Group 1 Sample D1 *(continued)*

SR	牛 SR Ox		
Characters	犟 stubborn	犁 plow	牟 moo

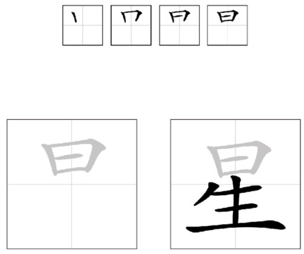
Writing instruction / Writing practice



SR Ox — Character Moo

SR	日 SR Sun		
Characters	早 morning	旱 drought	星 star

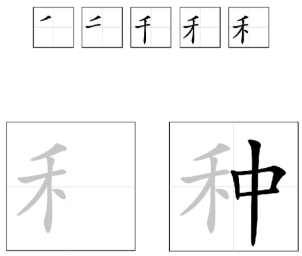
Writing instruction / Writing practice



SR Sun — Character Star

SR	禾 SR Standing grain		
Characters	秋 autumn	稻 paddy	种 seed

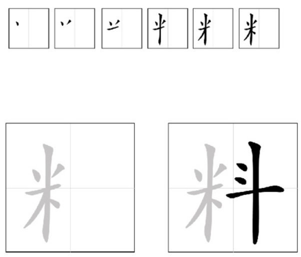
Writing instruction / Writing practice



SR Standing grain — Character Seed

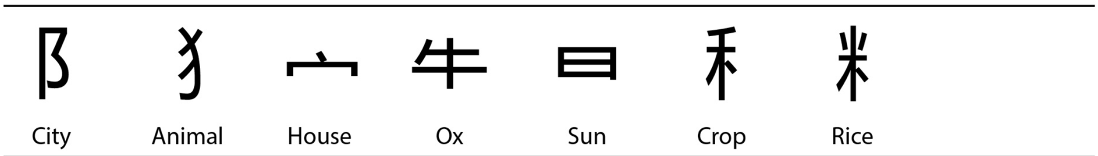
SR	米 SR Rice		
Characters	粮 food	糕 cake	料 feed

Writing instruction / Writing practice

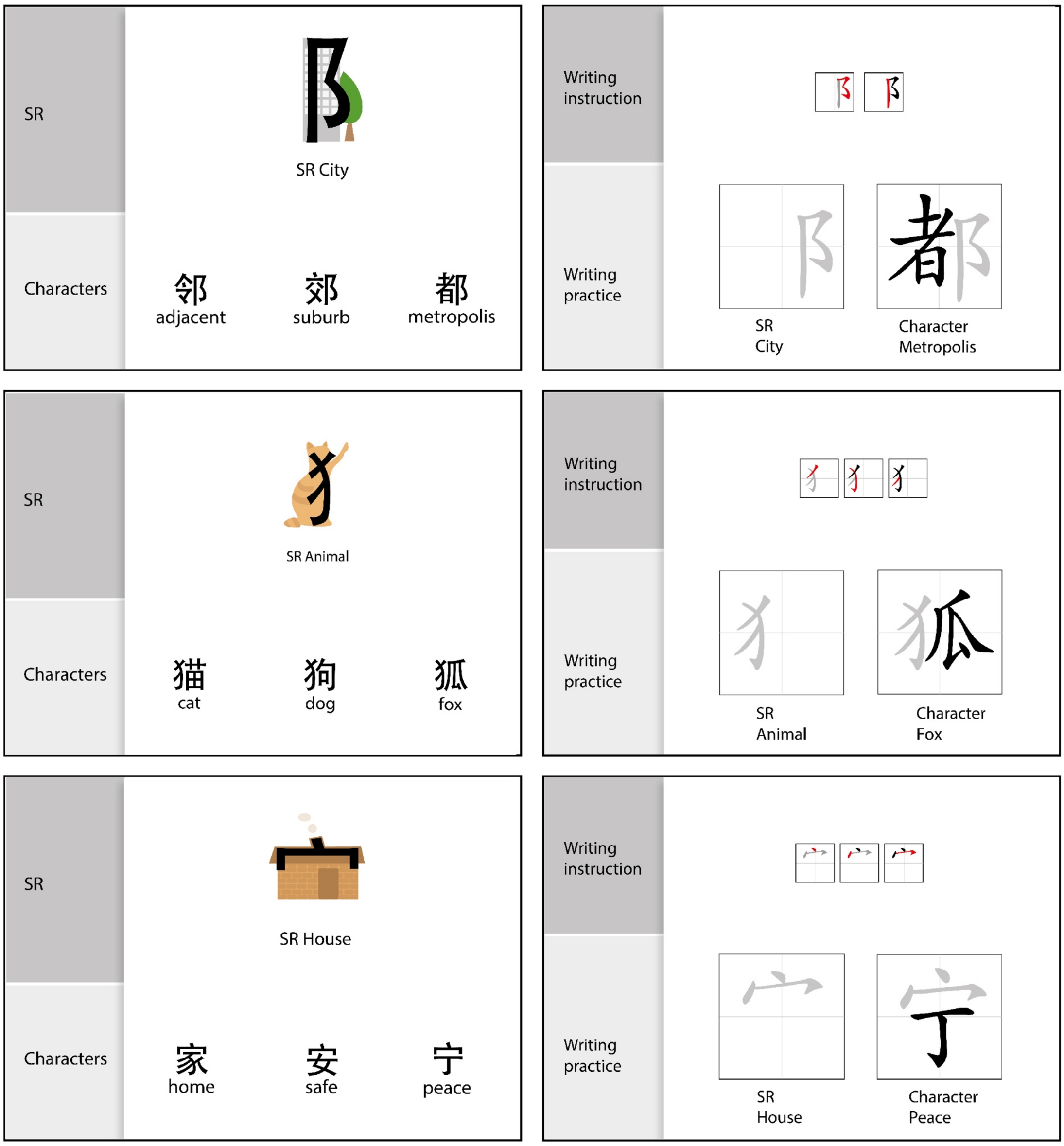


SR Rice — Character Feed

SR Group 1

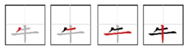
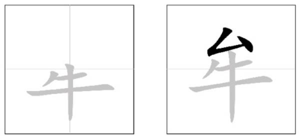


Sample D2

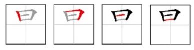


SR Group 1 Sample D2 *(continued)*

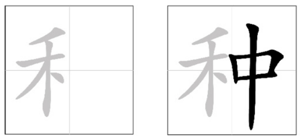
SR	 SR Ox
Characters	犟 stubborn · 犁 plow · 牟 moo

Writing instruction	
Writing practice	 SR Ox · Character Moo

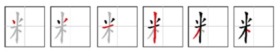
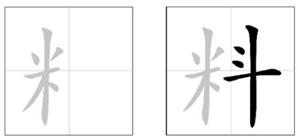
SR	 SR Sun
Characters	早 morning · 旱 drought · 星 star

Writing instruction	
Writing practice	 SR Sun · Character Star

SR	 SR Standing grain
Characters	秋 autumn · 稻 paddy · 种 seed

Writing instruction	
Writing practice	 SR Standing grain · Character Seed

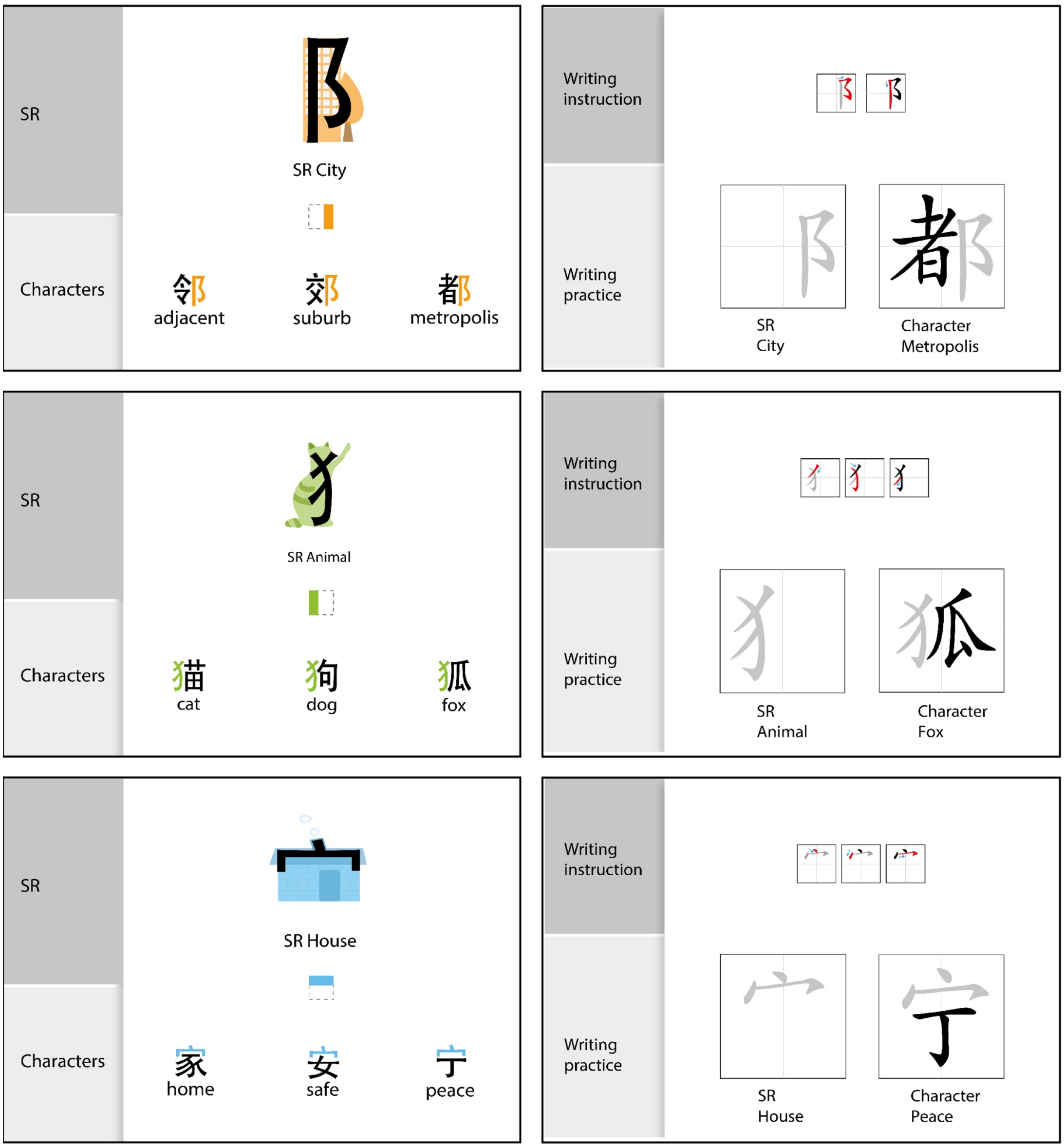
SR	 SR Rice
Characters	粮 food · 糕 cake · 料 feed

Writing instruction	
Writing practice	 SR Rice · Character Feed

SR Group 1

阝	犭	宀	牛	日	禾	米
City	Animal	House	Ox	Sun	Crop	Rice

Sample D3



SR Group 1 Sample D3 *(continued)*

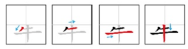
SR

SR Ox

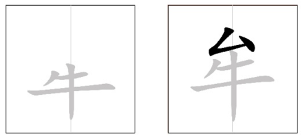
Characters

犟 stubborn | 犁 plow | 牟 moo

Writing instruction

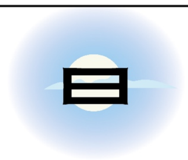


Writing practice



SR Ox | Character Moo

SR

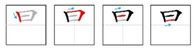


SR Sun

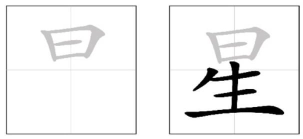
Characters

早 morning | 旱 drought | 星 star

Writing instruction



Writing practice



SR Sun | Character Star

SR

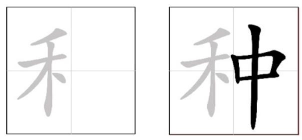
SR Standing grain

Characters

秋 autumn | 稻 paddy | 种 seed

Writing instruction

Writing practice



SR Standing grain | Character Seed

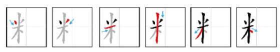
SR

Rice Radical

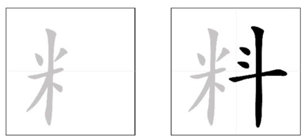
Characters

粮 food | 糕 cake | 料 feed

Writing instruction



Writing practice

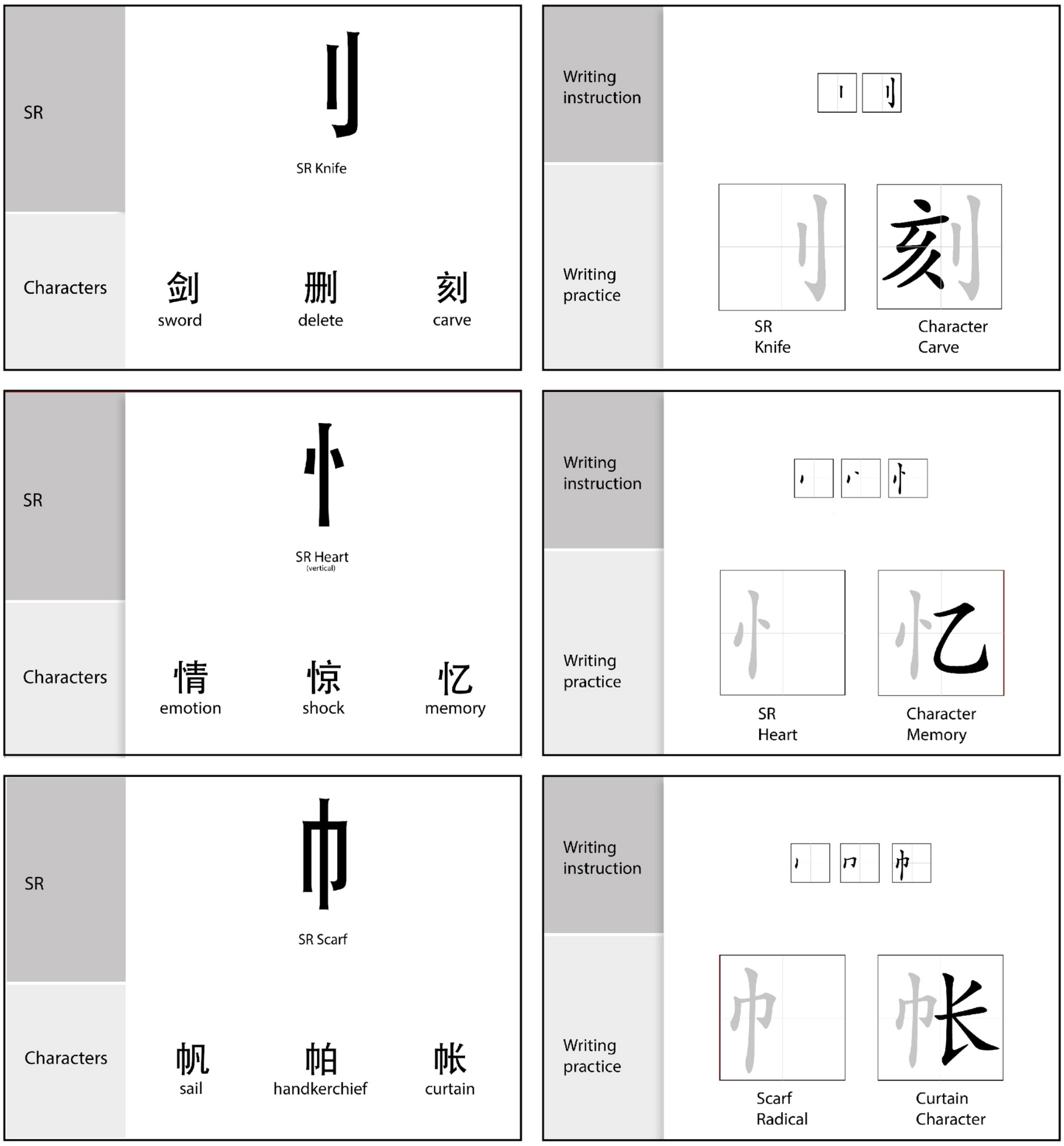


SR Rice | Character Feed

SR Group 2

刂	忄	巾	火	心	穴	虫
Knife	Heart	Scarf	Fire	Heart	Cave	Insect

Sample D1



SR Group 2 Sample D1 *(continued)*

SR	火 SR Fire (vertical)
Characters	灯 light · 烘 bake · 炊 cook

Writing instruction	丶 丷 火 火
Writing practice	火 SR Fire · 炊 Character Cook

SR	心 SR Heart (Horizontal)
Characters	想 miss · 感 sense · 忘 forget

Writing instruction	心 (stroke order)
Writing practice	心 SR Heart · 忘 Character Forget

SR	穴 SR Cave
Characters	穷 Poor · 窄 Narrow · 空 Empty

Writing instruction	穴 (stroke order)
Writing practice	穴 SR Cave · 空 Character Empty

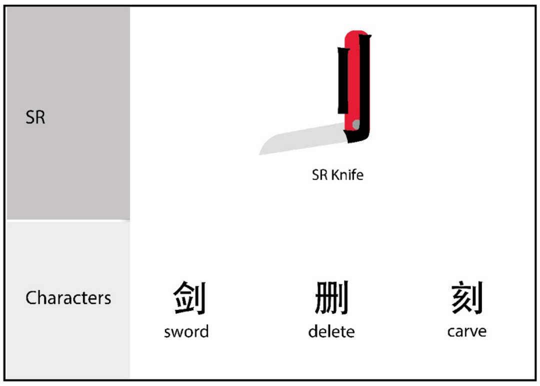
SR	虫 SR Insect
Characters	蚁 ant · 蚊 mosquito · 蜂 bee

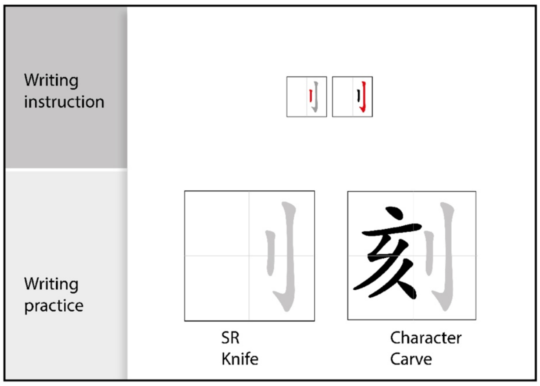
Writing instruction	虫 (stroke order)
Writing practice	虫 SR Insect · 蜂 Character Bee

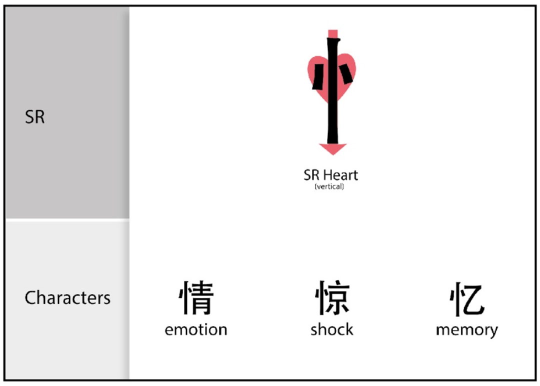
SR Group 2

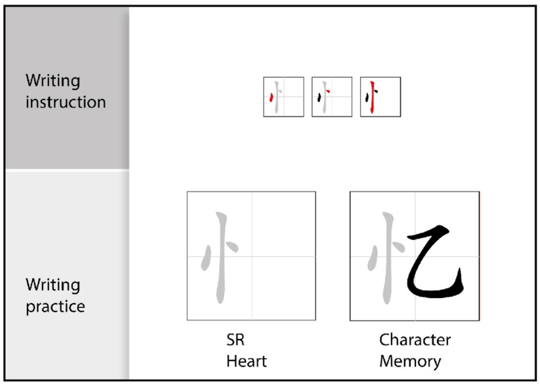
刂	忄	巾	火	心	穴	虫
Knife	Heart	Scarf	Fire	Heart	Cave	Insect

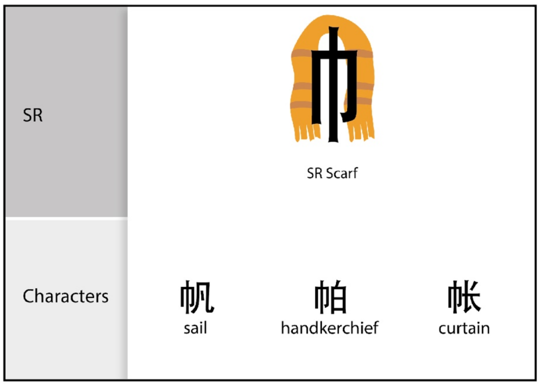
Sample D2

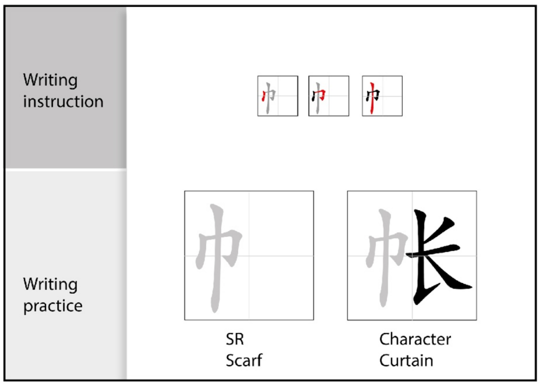












SR Group 2 Sample D2 *(continued)*

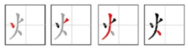
SR

SR Fire (vertical)

Characters

灯	烘	炊
light	bake	cook

Writing instruction



Writing practice

火	炊
SR Fire	Character Cook

SR

SR Heart (Horizontal)

Characters

想	感	忘
miss	sense	forget

Writing instruction

Writing practice

心	忘
SR Heart	Character Forget

SR

SR Cave

Characters

穷	窄	空
Poor	Narrow	Empty

Writing instruction

Writing practice

穴	空
SR Cave	Character Empty

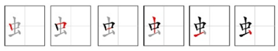
SR

SR Insect

Characters

蚁	蚊	蜂
ant	mosquito	bee

Writing instruction



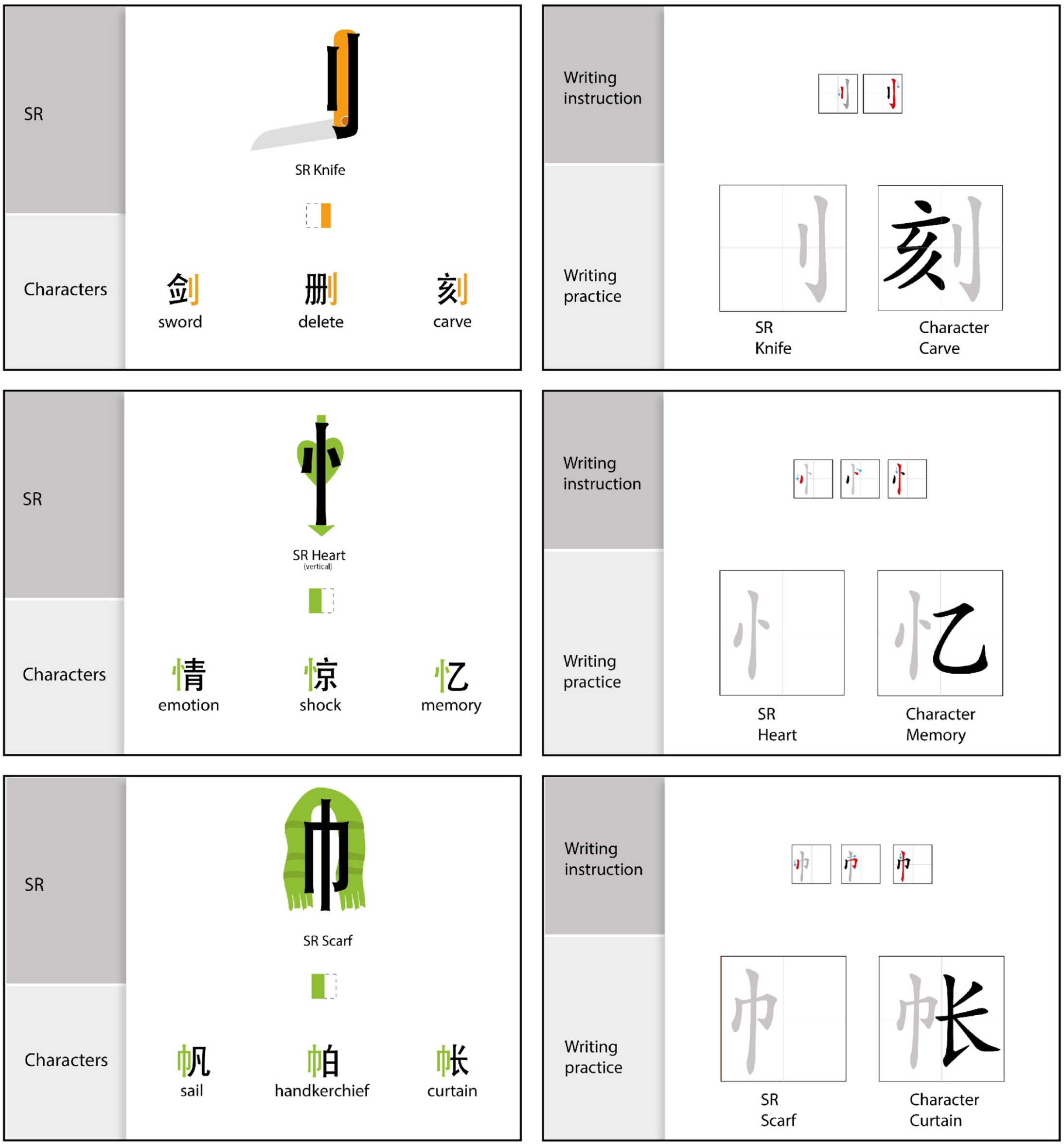
Writing practice

虫	蜂
SR Insect	Character Bee

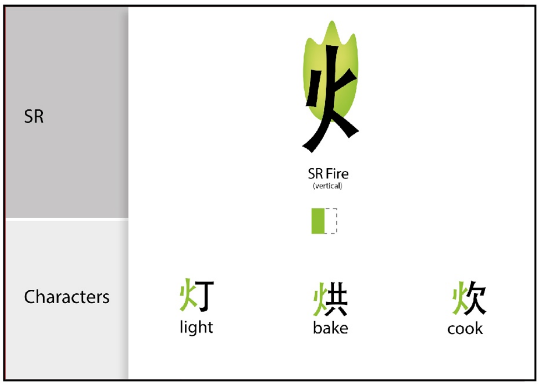
SR Group 2

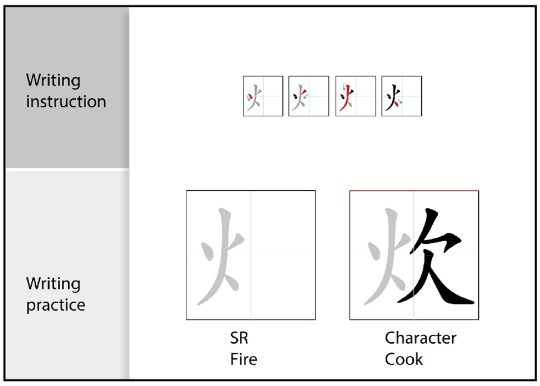
刂	忄	巾	火	心	穴	虫
Knife	Heart	Scarf	Fire	Heart	Cave	Insect

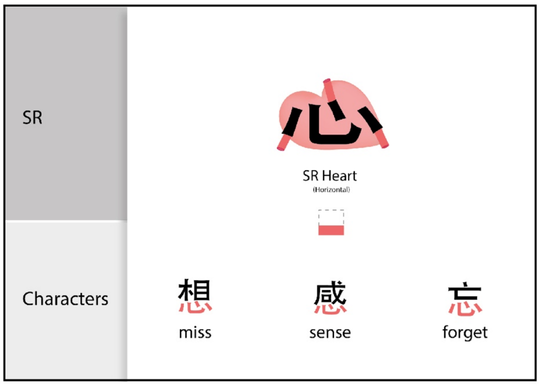
Sample D3

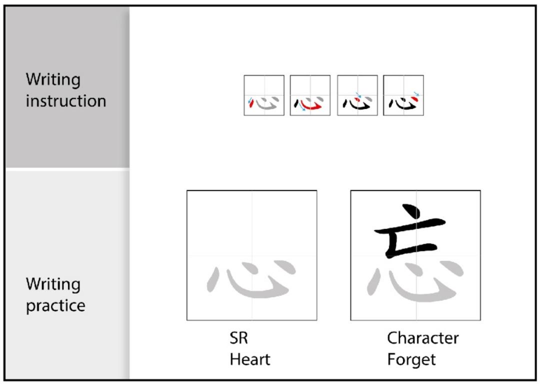


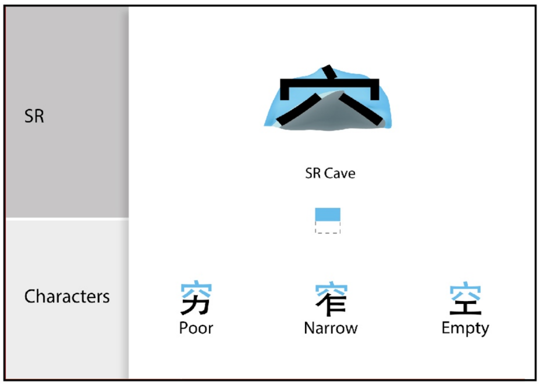
SR Group 2 Sample D3 *(continued)*

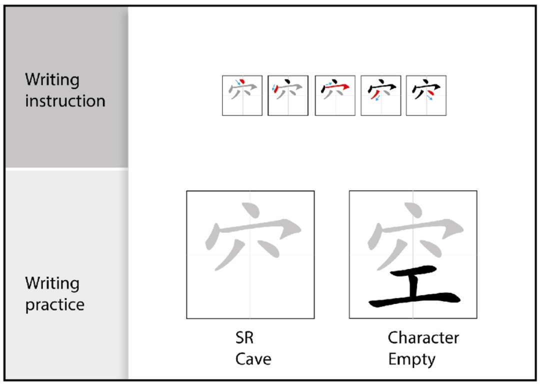


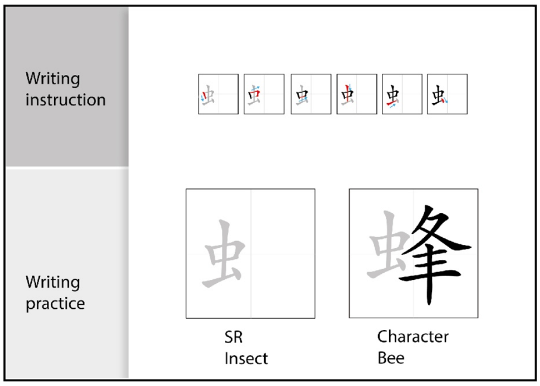




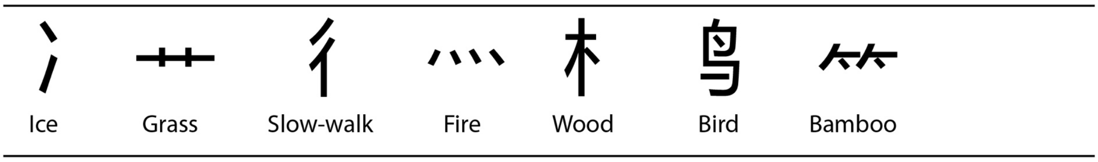




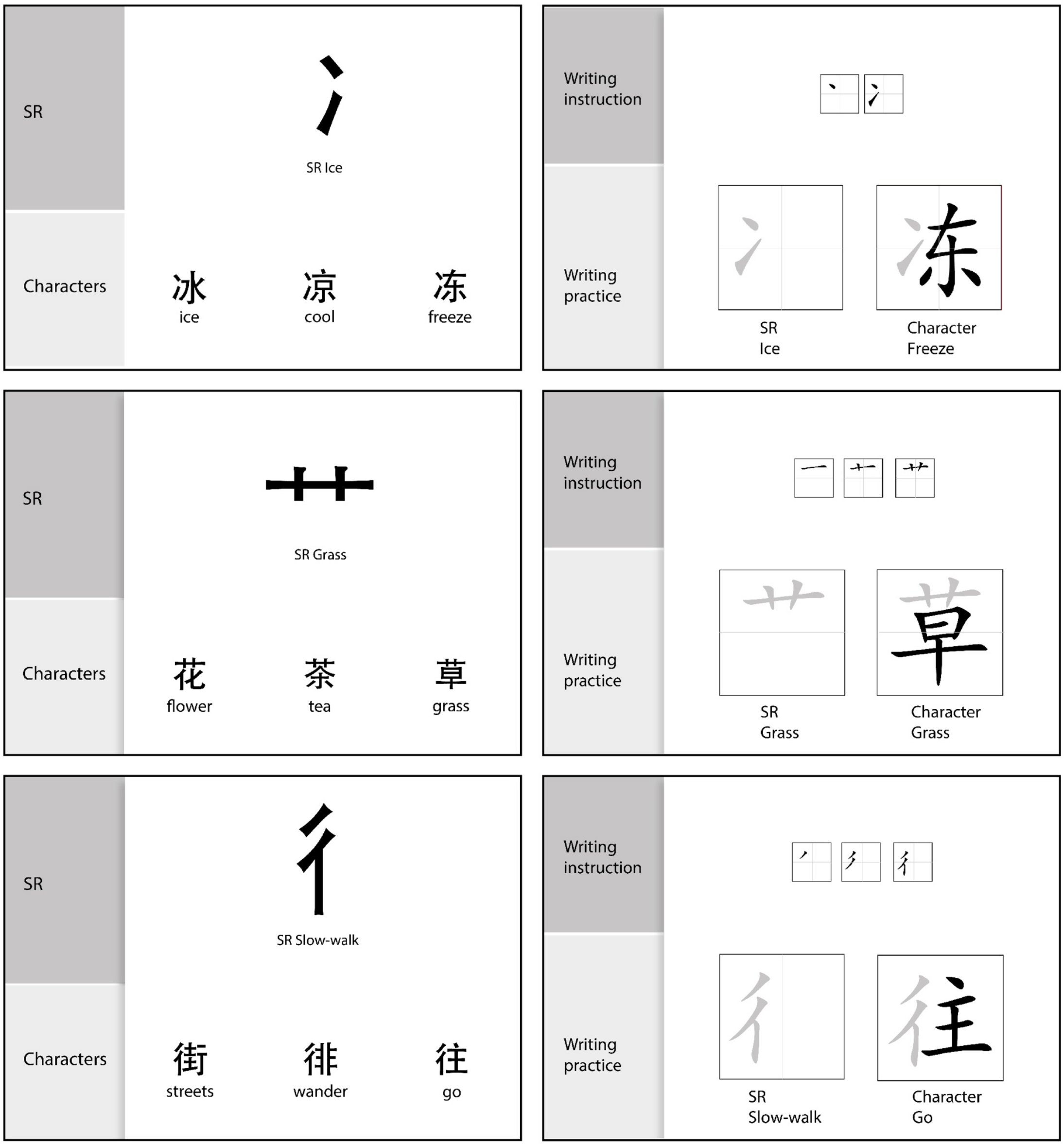




SR Group 3



Sample D1



SR Group 3 Sample D1 *(continued)*

SR	灬 SR Fire (Horizontal)		
Characters	点 set fire to	照 shine	煮 cook/boil

Writing instruction	灬	
Writing practice	灬 SR Fire	煮 Character Cook/boil

SR	木 SR Wood		
Characters	树 tree	桃 peach	材 timber

Writing instruction	一 十 才 木	
Writing practice	木 SR Wood	材 Character Timber

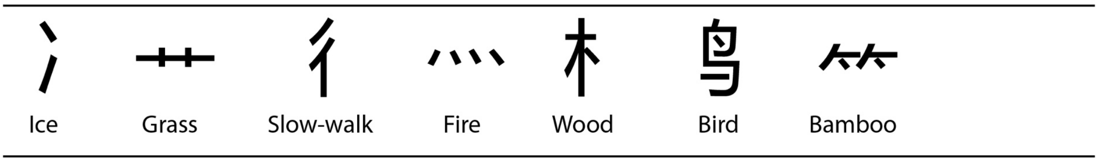
SR	鸟 SR Bird		
Characters	鸭 duck	鹦 parrot	鸥 gull

Writing instruction	鸟	
Writing practice	鸟 SR Bird	鸥 Character Gull

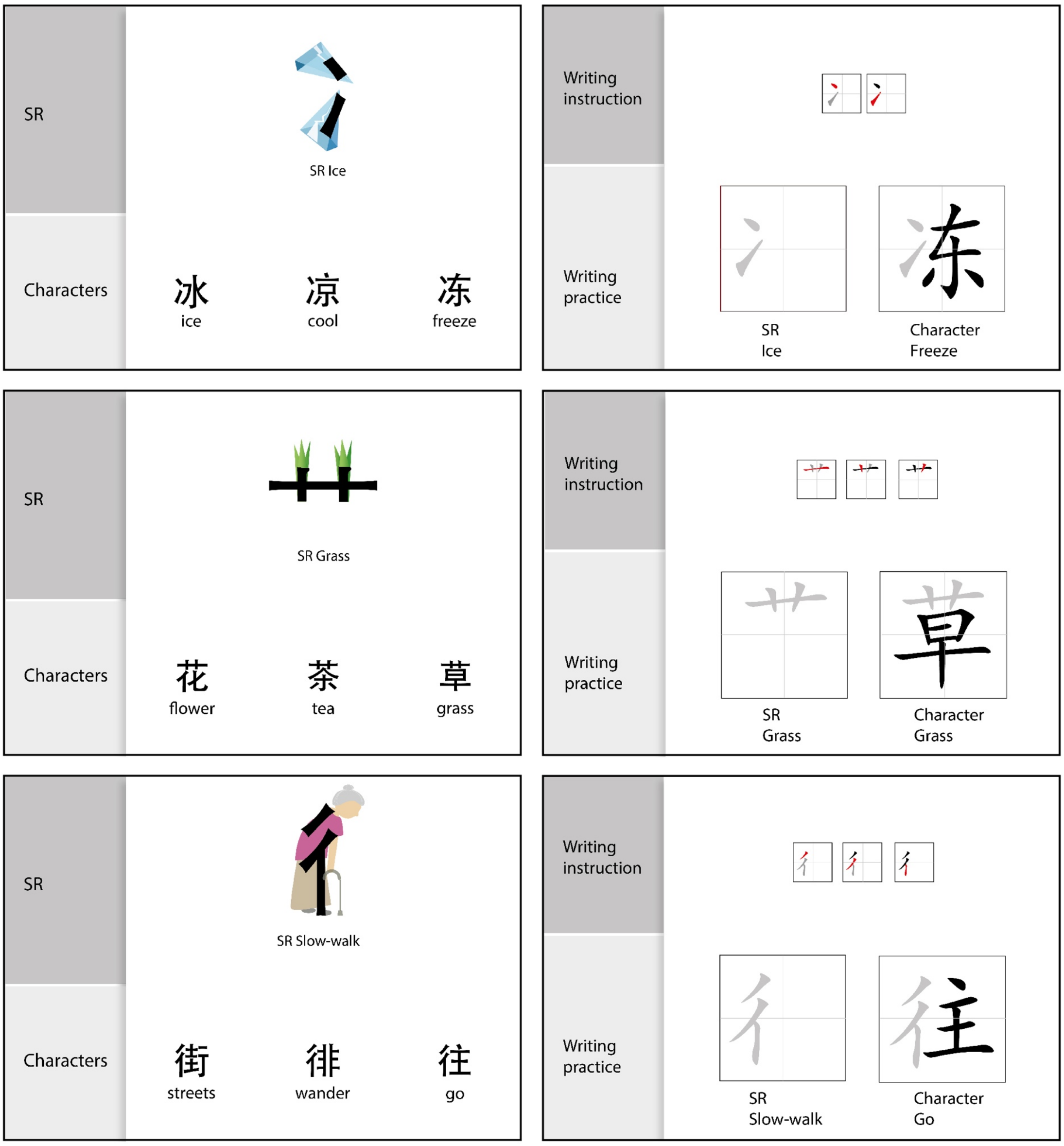
SR	⺮ SR Bamboo		
Characters	筐 basket	笔 pen	笛 flute

Writing instruction	⺮	
Writing practice	⺮ SR Bamboo	笛 Character Flute

SR Group 3



Sample D2



SR Group 3 Sample D2 *(continued)*

SR

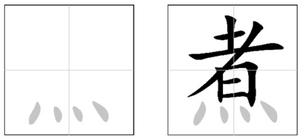
SR Fire (Horizontal)

Characters

点	照	煮
set fire to	shine	cook/boil

Writing instruction

Writing practice



SR Fire — Character Cook/boil

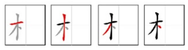
SR

SR Wood

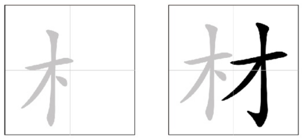
Characters

树	桃	材
tree	peach	timber

Writing instruction



Writing practice



SR Wood — Character Timber

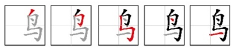
SR

SR Bird

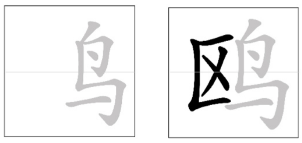
Characters

鸭	鹦	鸥
duck	parrot	gull

Writing instruction



Writing practice



SR Bird — Character Gull

SR

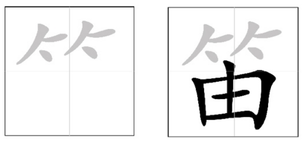
SR Bamboo

Characters

筐	笔	笛
basket	pen	flute

Writing instruction

Writing practice

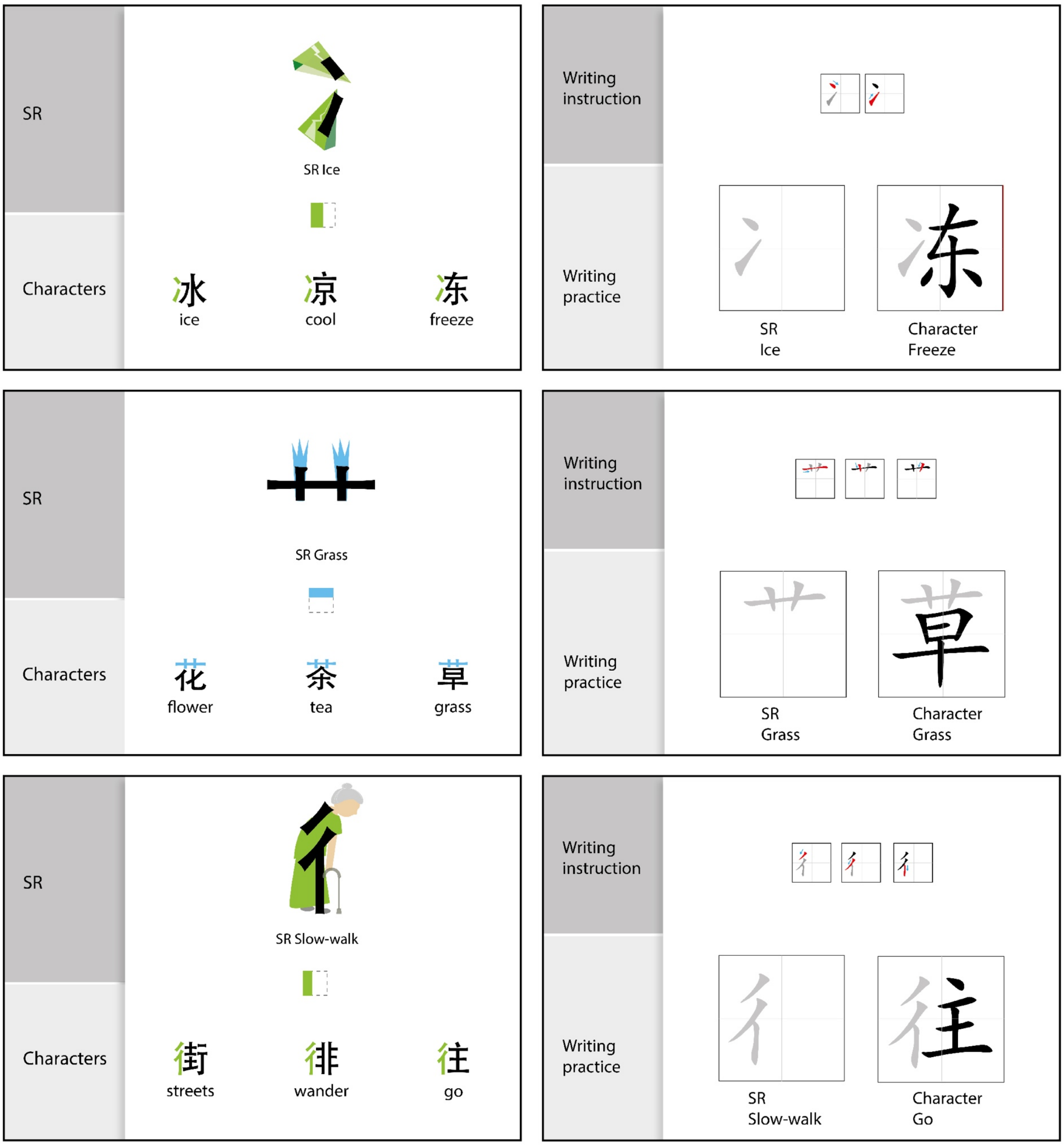


SR Bamboo — Character Flute

SR Group 3

冫	艹	彳	灬	木	鸟	⺮
Ice	Grass	Slow-walk	Fire	Wood	Bird	Bamboo

Sample D3



SR Group 3 Sample D3 *(continued)*

SR	 SR Fire (Horizontal)		
Characters	点 set fire to	照 shine	煮 cook/boil

Writing instruction		
Writing practice	灬 SR Fire	煮 Character Cook/boil

SR	 SR Wood		
Characters	树 tree	桃 peach	材 timber

Writing instruction		
Writing practice	木 SR Wood	材 Character Timber

SR	 SR Bird		
Characters	鸭 duck	鹦 parrot	鸥 gull

Writing instruction		
Writing practice	鸟 SR Bird	鸥 Character Gull

SR	 SR Bamboo		
Characters	筐 basket	笔 pen	笛 flute

Writing instruction		
Writing practice	⺮ SR Bamboo	笛 Character Flute