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Instructional Design for Non-specialist Beginners to Learn Chinese Semantic Radicals

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Abstract: The study investigates the effectiveness of instructional design for non-specialist beginners to learn Chinese Semantic Radicals (SRs). A Chinese SR is the smallest semantic component of a Chinese character. Research has shown that learning Chinese SR benefits the learning of Chinese characters by beginners. Research in this area is scarce with only a few studies investigating the application of related images to learn Chinese characters. This research investigates the performance and opinions of non-specialist beginners regarding four types of instructional designs: simply display, colour coding, illustration, and the combination of colour coding and illustration. The results confirmed that the combination of illustration and Chinese SR has the functions of visualisation, translation and memorisation. Colour coding has the function of position highlighting and memorisation. These research-based findings are an important contribution to knowledge and can inform future design and research when it comes to teaching Chinese SRs for non-specialist beginners.

Keywords: instructional design; illustration; colour coding; effectiveness

1. Introduction

Chinese is the second of the ten most important languages for the UK's economic, cultural and educational future (Tinsley & Board, 2017). Chinese characters play a vital and irreplaceable role in the acquisition of Chinese as a second language. Semantic Radicals (SRs) are the smallest semantic components in Chinese characters (Hoosain, 1991; Qian, 2009; Shen & Ke, 2007). For example, Figure 1 shows that the SR "Hand" is included in Hit, Pull and Push characters. It is obvious to see that characters which have the SR "Hand" are related to "Hand". Many researchers stated that Chinese-language beginners benefit from learning Chinese SR (Chan & Nunes, 1998; Packard et al., 2006; Su, 2010). The knowledge of Chinese SR includes its meaning and position (Shen & Ke, 2007; Su, 2010), which are regarded as learning tasks and instruction goals in this study.

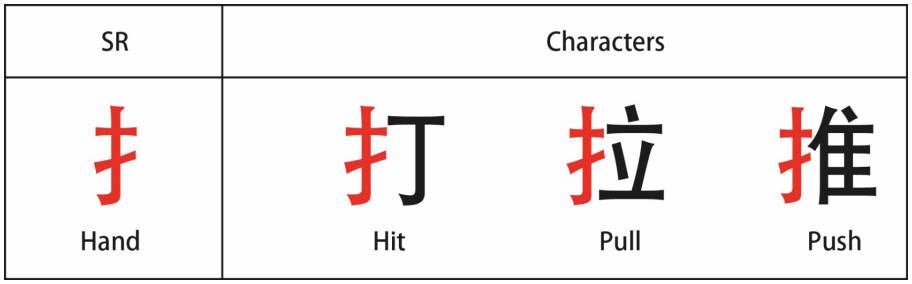

Figure 1 An example of Chinese SR and related characters.

This study focuses on non-specialist beginners, which are defined as learners who are not taking a degree study in a language (Canning, 2011). Interviews with five Chinese language teachers revealed the difficulties of learning Chinese SRs for non-specialist beginners. Results from interviews showed that non-specialist beginners have very limited time to learn Chinese characters or Chinese SRs in class time, and they normally spend little time to learn it after class. This means non-specialist learners need more effective instructions for learning Chinese SRs. Cohen (2014) suggests that Western learners might need a variety of visual aids for learning Japanese kanji (original Chinese characters).

Chinese characters are logograms and some of them are iconic, which means that the way some Chinese characters and SRs are written makes them appear what they represent (Chen & Tzeng, 1992; Potowski, 2010). Some studies have provided evidence that the iconicity of Chinese characters benefits the acquisition of Chinese characters (Chan, Leung, Luo, & Lee, 2007; Luk & Bialystok, 2005; Shu, Chen, Anderson, Wu & Xuan, 2003). The iconicity of Chinese characters (including SRs) is their feature, which should be taken into consideration in instructional design.

2. Visual instructions for language learning

The research of visual presentations in instructional design for enhancing learning is not scarce in the field of language education. 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 languages (Snyder and Colon, 1988). Colour mark is recommended to increase the effectiveness of learning Russian language (Birzer and Zinsmeister, 2016). Moreover, images and graphic organisers bring a positive impact on learning English root words (Gill, 2007), which is similar to Chinese SRs to some extent.

In terms of learning Chinese characters, Wang and Thomas (1992) state that imagery-based mnemonics are beneficial to the short-term retention of Chinese characters compared with rote learning; though Kuo and Hooper (2004) argued such “a picture representing a concrete or abstract word” (p.26) approach does not yield to significant benefits. Wang (2014) stated that learning Chinese characters with animation is significantly more effective than learning Chinese characters with text-only.

Previous studies (Kuo & Hooper, 2004; A. Y. Wang & Thomas, 1992) support the potential effectiveness of instructional design for learning Chinese SRs.

However, few studies test the effectiveness of different static infographics for learning Chinese SRs. Moreover, the visual instructions for language learning in the previous studies were presented as extra and independent information for describing the content of targeting knowledge. For improving the effectiveness of the instructions, the theories and suggestions of infographic instructions are stated in Section 3.

3. Infographic instructions for effective learning

The main purpose of infographic design is to organise and present information via visual graphics in order to communicate with target audiences effectively (Pettersson, 2002; Smiciklas, 2012). Infographic instructions make the acquisition of knowledge more efficient and accessible (Merrill, Drake, Lacy, Pratt, & Group, 1996; Reiser & Dempsey, 2012). The theoretical basis and the effectiveness of different visual approaches will be explored next.

Dual Coding Theory proposes that both visual coding and verbal coding are independent cognitive systems for processing information (Paivio, 1986). The effectiveness of instructions in learning materials may be increased by stimulating with visual and verbal materials rather than only verbal representation (Clark & Paivio, 1991). Regarding infographic instructions, this theory has been used as theoretical support in many studies (Carney & Levin, 2002; Vekiri, 2002). Moreover, the Picture Superiority effect refers to the phenomenon that human memory is more sensitive to visual information than verbal information (Curran & Doyle, 2011; Defeyter, Russo & McPartlin, 2009). The cognitive load theory suggests that instructions should not split learners' attention from various sources of information and they should integrate multiple sources of information physically (Chandler and Sweller, 1991).

Different infographic instructions have different functions for effective learning. Images and colour are widely used in infographic instructions. Based on the targeting learning tasks, the potential functions of images have been explored and listed below by reviewing the studies conducted by Ainsworth, (1999, 2006), Levin & Mayer (1993) and Marsh and Domas White (2003).

- Visualise: images provide visible representations.
- Translate: images repeat the same content from verbal information.
- Memorise: images help to memorise information.

The potential functions of the colour application have been suggested and listed below (Ainsworth, 1999; Chandler & Sweller, 1992; Keller, Gerjets, Scheiter & Garsoffky, 2006; Smallman & Boynton, 1993).

- Relate: colour provides clear visual instructions to show relationships.
- Highlight: colour emphasises the important parts of the whole.
- Memorise: colour help to memorise information.

However, the instructions in the previous studies were presented as independent and separate information rather than physically integrated. Moreover, the functions and effectiveness of instructional design are not always universal and depend on the type of instructions, learners and learning tasks (Clark, Lyons & Hoover, 2010; Gyselinck & Tardieu, 1999; Kalyuga et al., 2004; Kalyuga & Sweller, 2014).

The aim of this study is to explore how instructions with illustration and colour coding affect the recognition behaviour for learning Chinese SRs. A performance task was designed to test non-specialist beginners' short-term memory. This was followed by a post-test questionnaire to explore the functions of different infographic instructions.

4. Methods

To investigate the effectiveness of different infographic instructions for non-specialist learners, a performance test and a post-test questionnaire have been conducted with 16 participants. The effectiveness was explored by measuring the accuracy. The instruction with illustration in this paper is defined as the combination of illustration and SR. The instruction materials in this study include: (i) illustration which integrates graphics presentation and SR, and (ii) colour coding which a different and chromatic colour is applied to part of the character for denoting the position of the Chinese SR.

The research hypotheses have been formulated as below:

- Hypothesis 1: Instruction with illustration increases memorising the meanings of Chinese SRs.
- Hypothesis 2: Instruction with colour coding increases memorising the positions of Chinese SRs.

4.1 Participants

A total of 16 participants (8 female and 8 male) were recruited with a mean age of 21 years old. All the participants were non-specialist beginners from non-Chinese speaking countries (India, Ireland, Mexico, Pakistan, Poland, Saudi Arabia, Spain and UK).

4.2 Instruction materials

The instruction materials used in this study consist of four types of learning instructions with sixteen Chinese SRs. Each instruction has four SRs, and each has specific and concrete meanings. The difficulty level of SRs is determined by the number of strokes. The total number of strokes for each group has been determined in the range of 13-15 strokes. Figure 2 shows the 16 SRs with an English translation and stroke numbers.

city	hand	cave	horse	knife	grain	grass	fire
2	3	5	3	2	5	3	4
talk	house	female	clothe	ice	slow-walk	fire	bamboo
2	3	3	5	2	3	4	6

Figure 2 *Sixteen SRs and their corresponding meaning and stroke number.*

Figure 3 shows examples of the four types of learning instructions. Each SR was displayed with three characters which share the same SR. Participants were asked to memorise the Chinese SRs rather than characters; the characters were displayed to help participants to understand the relationship between the targeting SR and the related characters. Type one is a simple display with black position highlight. Type two instructs radicals with colour coding for learning position. Different Chinese SRs have different positions. Normally, SR has the top, bottom, right and left position. The different position shows with different colours: green for left, orange for right, blue for top and brown for bottom. Type three instructs radicals with an illustration integrated with SR. The illustration visualised the meaning and followed the shape of the radical. Type four is a combination of type two and type three.

Figure 3 *The 4 types of learning instructions: (1) Simply display, (2) Colour coding, (3) Illustration, (4) Illustration and colour coding.*

4.3 Procedure

The whole procedure of the experiment has three main parts:

- Learning task
- Memorisation task
- Post-test questionnaire

Participants were provided written explanatory materials, to learn about what Chinese SRs refer to and their relationship to Chinese characters, before they started the learning task. For the learning task, the participants were given 20 seconds to study each of the 16 SRs (i.e. 4 types of learning instructions x 4 SRs under each type).

Once the learning task was completed, the participants were required to take on the memorisation task. The memorisation task was set in form of a multiple-choice quiz with 3 questions for each of the SRs and only one answer should be given out of the 4 possible options in each question:

- Meaning Recall (MR): To choose the meaning when offering the SR.
- Radical Recall (RR): To choose the SR when offering the meaning.
- Position Recall (PR): To choose the position when offering the SR.

All the questions were randomised to minimise any bias. The participants were allowed an unlimited amount of time to answer all the questions. After the memorisation task was completed, the participants were asked to fill in a five-point Likert scale questionnaire. The questionnaire was set to attempt confirming the functions the functions of illustration and colour coding.

4.4 Analysis

All the data have been tested for normality with the Shapiro-Wilk test. All the p-values1 of the data are smaller than 0.05, therefore, all the data are non-normal distribution (Royston, 1992). The Wilcoxon signed-rank test (Woolson, 2008) is a non-parametric statistical test to compare the differences between two matched samples. The descriptive statistical data of all groups was to compare the means of different groups. The Wilcoxon signed-rank test was conducted to compare the accuracy of the four groups. If the p-value of the Wilcoxon signed-test is greater than 0.05, the two groups have no significant difference. If the p-value is less than 0.05, the two groups have a significant difference. If the p-value is less than 0.01, the two groups have a highly significant difference.

1 The p-value is the probability value in statistical hypothesis testing (Wasserstein & Lazar, 2016).

5. Results

5.1 Memory test accuracy

The descriptive statistic result of the memory test accuracy is shown in Table 1. Figure 4 illustrates the p-value of the Wilcoxon signed-test for the four different types. The result shows obvious trends of different questions among Type one (T1), Type two (T2), Type three (T3) and Type four (T4).

For the MR question, Table 1 shows the means of four types: T1 (M=69%) < T2 (M=72%) < T4 (M=89%) < T3 (M=95%). The result of statistical test (Figure 5) reveals that T1 (M=69%) and T2 (M=72%) do not have a significant difference ($p>0.05$). T3 (M=89%) and T4 (M=95%) do not have a substantial difference ($p>0.05$). The MR accuracy for T1 (M=69%) is highly significantly lower ($p <0.01$) than T3 (M=89%), and significantly lower ($p <0.05$) than T4 (M=95%). The MR accuracy for T2 (M=72%) is highly significantly lower ($p <0.01$) than T3 (M=89%), and significantly lower ($p <0.05$) than T4 (M=95%).

For the RR question, the means of the four types could be ordered as T1 (M=63%) < T2 (M=77%) <T4 (M=88%) < T3 (M=98%). The accuracy of T1 (M=63%) is significantly lower ($p<0.05$) than T2 (M=77%), highly significantly lower ($p<0.01$) than T3 (M=98%), and significantly lower ($p<0.05$) than T4 (M=88%). T3 (M=98%) is highly significantly higher ($p<0.01$) than T2 (M=77%), and significantly higher ($p<0.05$) than T4 (M=88%). The accuracy of T2 (M=77%) and T4 (M=88%) does not have a large difference ($p>0.05$) (Figure 4).

For the PR question, T2 (M=81%, SD=14%) ≈ T3 (M=81%, SD=27%) > T4 (M=67%) > T1 (M=45%). The statistical result (Figure 4) shows that the accuracy of T1 (M=45%) is highly significantly lower than T2 (M=81, $p<0.01$), T3 (M=81%, $p<0.01$) and significantly lower than T4 (M=67%, $p<0.05$). T2 (M=81%) does not have great difference with T3 (M=81%, $p>0.05$) and T4 (M=67%, $p>0.05$). The accuracy of T3 (M=81%) is noticeable higher ($p<0.05$) than T3 (M=67%).

In summary, instructional design with colour coding only (T2) shows great higher accuracy for answering the PR question. Instructional design with illustration only (T3) has significant higher accuracy for learning Chinese SR in terms of answering all the three questions (MR, RR and PR). Instructional design with the combination of colour-coding and illustration (T4) shows obvious higher accuracy for answering MR and RR questions, however, T4 shows significant lower accuracy than T3 in terms of the PR question.

Table 1 The result of the memory test accuracy.

Accuracy	Type	Mean	SD	N
MR Question	T1	69%	25%	16
	T2	72%	29%	16
	T3	95%	10%	16
	T4	89%	22%	16
RR Question	T1	63%	24%	16
	T2	77%	14%	16
	T3	98%	6%	16
	T4	88%	22%	16
PR Question	T1	45%	28%	16
	T2	81%	14%	16
	T3	81%	27%	16
	T4	67%	33%	16

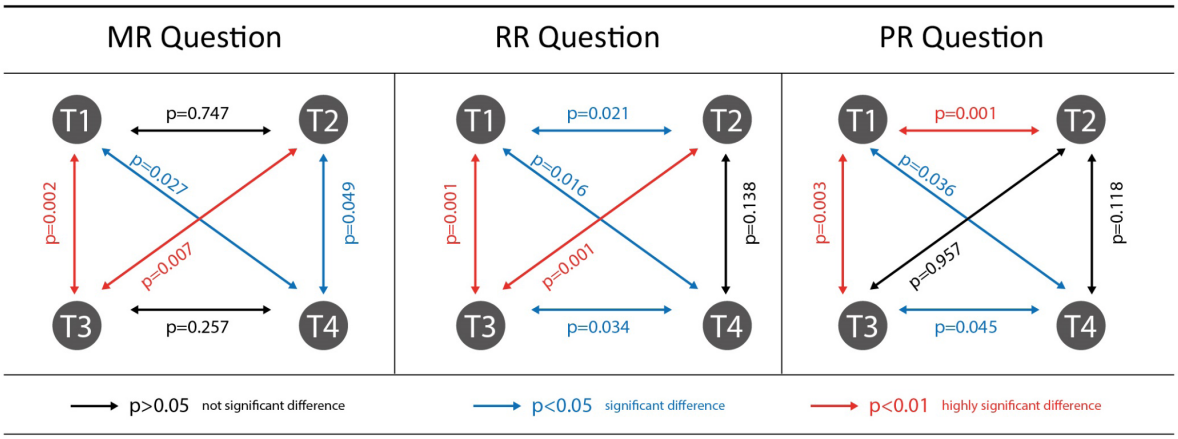

Figure 4 Wilcoxon Signed Ranks Test p-value for Memory test Accuracy.

5.2 Questionnaire

The questionnaire helps to explore the various functions of illustration and colour coding. The five-point Likert scale was developed to measure the agreement of different functions: 1=strongly disagree, 2=disagree, 3=neutral, 4=agree and 5=strongly agree. Table 2 displays the results, 87.5% (31.25% agree and 56.25% strongly agree) of participants confirm the function of visualisation; all participants (18.75% agree and 81.25% strongly agree) believe illustration has the function of translation. The majority of participants (93.75% from which 12.50% agree and 81.25% strongly agree) think illustration helps to memorise radicals' meaning.

Most participants (81.35% from which 25% agree and 56.35% strongly agree) agree that illustration helps to highlight the shape of radicals.

Table 2 The Results of illustration functions from Likert scale questionnaire.

Illustration functions	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)
Visualisation	0.00%	6.25%	6.25%	31.25%	56.25%
Translation	0.00%	0.00%	0.00%	18.75%	81.25%
Meaning Memorisation	0.00%	0.00%	6.25%	12.50%	81.25%
Shaping Highlighting	0.00%	6.25%	12.50%	25.00%	56.25%

Table 3 presents the results of functions of colour coding for learning Chinese SR. Majority of participants (25% agree and 50% strongly agree) believe that colour coding highlights the position of each SR. Many participants agree with the function of position memorisation (68.75% from which 31.25% agree and 37.5% strongly agree). More than half of participants (68.75%) approve that colour coding breaks down the whole characters into components. More than three quarters of participants (12.25% agree and 68.75% strongly agree) found the colour-coding helps to know the structural relationship between Chinese SR and complete characters.

Table 3 Results of colour coding functions from Likert scale questionnaire.

Colour-coding Functions	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)
Position highlighting	0.00%	6.25%	18.75%	25.00%	50.00%
Position memorisation	6.25%	6.25%	18.75%	31.25%	37.50%
Breaking down	0.00%	12.50%	18.75%	25.00%	43.75%
Relate	0.00%	0.00%	18.75%	12.50%	68.75%

In summary, the majority of participants agreed that the combination of illustration and Chinese SR visualises and translates the meaning of radicals. Moreover, it helps to memorise the meanings of SRs and highlights the shapes of SRs. In terms of colour coding, most participants agreed that colour coding has functions of position highlighting and position memorisation. In addition, many participants agreed that colour coding helps to break down the whole character into components and it helps to understand the structural relationship between Chinese SR and complete characters.

6. Discussion

This study investigated different instructional designs for non-specialist beginners to learn Chinese SRs. The memory test task ascertains the effectiveness (measured by accuracy) of different instructional designs. The questionnaire confirmed various functions of illustration and colour coding. The study is using an experimental approach to examine the impact of illustration (integrated with radicals) and colour coding for learning Chinese radicals.

The findings of the memorisation task align with previous studies (Kuo & Hooper, 2004; Wang & Thomas, 1992) and further develop the theories of instructional design for learning Chinese SRs. In the memory test, the results are in line with Dual coding theory (Paivio, 1986) and Picture Superiority effect showing that instructional design facilitates the acquisition of knowledge (Clark & Paivio, 1991). Specifically, the results of memory test accuracy for answering Meaning-Recall questions and Radical-Recall questions confirm Hypothesis 1 that instruction with illustration increases memorising the meaning of Chinese SR. The results not only prove that illustration helps to recall from radical to meaning (MR question), but also the other way around, from meaning to radical (RR question). This is in agreement with the visualising, translation and memorising functions with illustration (Ainsworth, 1999; Ainsworth, 2006; Levin & Mayer, 1993; Marsh & White, 2003). All the above functions have been confirmed with participants.

As colour has been identified as important in enhancing memory (Chandler & Sweller, 1992; Keller et al., 2006; Smallman & Boynton, 1993), this result of memory test accuracy (G1 and G2 for PR question) and the result of post-test questionnaire confirm the efficiency of colour-coding (Hypothesis 2). These experimental results confirm the efficiency of colour-coding, specifically on memorising SRs' positions, which can be further popularised in the instructional design for learning Chinese Radicals. The results expose the highlight and relate function (Ainsworth, 1999; Chandler & Sweller, 1992; Keller et al., 2006; Smallman & Boynton, 1993), which emphasises the position and the relationship between Chinese characters and SRs. Moreover, a new function of colour coding as an instructional design approach when learning Chinese SRs is break down, which means the colour split SRs from complete Chinese Characters. Learners also confirmed that colour coding facilitates knowing the relationship between Chinese SRs and the whole characters. This help learners to know an SR is a part of Chinese Characters by colour coding.

Based on the result of the study, illustration and colour coding have different functions in terms of different learning tasks. The data reveals a decrease in accuracy when applying illustration and colour coding together; this might be because of too many instructional information, such as too many colours. For future research, reducing the number of different colours for the instructional design might be a solution.

This study supports and suggest (Clark et al., 2010; Kalyuga & Sweller, 2014) the effectiveness of different instructional design approaches is different in various learning tasks. The results suggest that instructional design should be approached more directly for specific problems when learning Chinese SRs. The questionnaire further supports the various functions

for illustration and colour coding separately, as confirmed by participants. Additionally, governments of many countries increasingly emphasise the great importance of the acquisition of the Chinese language. For example, it is noted Saudi Arabia started to take the Chinese language into its educational curriculum in 2019 ("Saudi Arabia plans", 2019). This means that the research of instructional design for learning Chinese SR is of significant importance to help meet such demand. Since the target audience of this study is general Chinese learners, special conditions like colour blindness or dyslexia were not considered, which is a limitation of this study and a topic to be addressed in the future.

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