

# **Empirical Evidence on Character Recognition in Multimedia Chinese Tasks<sup>1</sup>**

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The present study reports the findings concerning the effects of multimedia and processing experience on Chinese character recognition. One hundred twenty English speaking university students who were L2 learners of Chinese performed a recall task on 36 Chinese characters displayed on a computer with three types of multimedia presentations, focusing on word formation rules (radicals), character stroke sequences, and pronunciation (Pinyin). The results indicate that participants who worked with the radical presentation performed best, and the performance of those who worked with the stroke presentation was in turn better than those working with the Pinyin presentation. The experiment found that in addition to effective multimedia, three critical factors contribute to the success of Chinese character recognition: (a) L2 processing strategies which are different from L1, (b) increased overall L2 linguistic knowledge, especially orthographic knowledge of Chinese radicals and strokes, and finally (c) metalinguistic awareness, i.e. sensitivity to orthographic regularity.

Key words: multimedia, character acquisition, radical, stroke, and Pinyin presentations, processing strategies, and orthographic regularity

## **1. Introduction**

Learning, as Kazma (1991), Mayer (1997) and others have pointed out, is an active, constructive process whereby the learner strategically manages the available cognitive resources to create new knowledge by extracting information from the environment and integrating it with information already stored in memory. With the rapid development of computer technology and its application in language instruction, many researchers in the past ten years have engaged in the study of this kind of active and constructive learning process in multimedia environment. Researchers have found that a multimedia learning environment provides the means to facilitate the learning process by manipulating the availability of specific information at a given moment, by controlling the duration of that availability, by varying the way the information is presented, and by ensuring the ease with which it can be searched. A generative theory

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of multimedia learning (GTML) as applied to second language learning has emerged as a result of many empirical studies, e.g., Chun and Plass 1997; Mayer, et al., 1995; Mayer, 1997; and Plass, et al., 1998.

Drawing upon the empirical results of Wittrock's (1974, 1990) generative theory and Paivio's dual coding processing theory, the generative theory posits that when learners are presented with visual (animation, video clips, pictures, etc.) and verbal (text) information, such as in multimedia programs, they engage in three processes—selecting, organizing, and integrating—that is, learners actively select relevant verbal and visual information, organize the information into coherent mental representations, and integrate these newly constructed visual and verbal representations with one another. In a number of empirical studies, the researchers were able to show that the multimedia presentation promotes learning, and for whom multimedia instruction is especially effective. The present article is concerned with three questions related to the generative theory, namely, (a) whether different types of multimedia presentations will have differing effects on learners' ability in Chinese character recognition, (b) whether L2 processing experience plays a role in Chinese character recognition in a multimedia learning environment; and (c) whether alphabetic L1 learners transfer their orthographic processing strategies to Chinese character recognition.

## **2. Previous Research on Multimedia Learning and Word Recognition**

The research questions on L2 multimedia learning and L2 character recognition processes encompass a number of different perspectives, for example, whether information presented verbally and visually will have any effect on the learner's vocabulary or character learning, how the amount of L2 orthographic processing experience will affect L2 word recognition, the role of L1 orthographic background in word processing, the extent to which the L1 and L2 orthographic systems share similar structural and representational properties, and how orthographic knowledge bases of L1 and L2 interact with each other. The research questions addressed in this article, however, restrict the review on L2 multimedia word/character recognition research to mainly the following three perspectives: (a) L2 processing experience effects; (b) the L1 processing experience effects; and (c) the value and effect of visual information for

character recognition and learning.

With regard to the effects of visual and verbal information on word recognition and learning, two related empirical studies will be reviewed. Lyman-Hager et al. (1993) investigated the question of whether a computerized dictionary with the capability of instantaneous look-ups will result in greater mastery of vocabulary words. Two groups of L2 learners of French were examined, one that used interactive reading software and one that did not. All students read a passage in French in the language laboratory, but the computer group received assistance on line while the non-computer group had access to printed pages of glosses drawn directly from the computer program. Both had pictures for difficult-to-define concepts. The results for the vocabulary quiz containing 20 words from the story showed that students who worked with the on-line dictionary had significantly better scores on the quiz than those who did not work with the computer program.

Chun and Plass (1996) investigated the effects on multimodal annotation in vocabulary acquisition, among other things. With 160 university students of German using CyberBuch, the researchers presented reading materials in the format of text, pictures, and video. Three areas were examined: whether vocabulary would be learnt incidentally, the effectiveness of different types of annotations for vocabulary items, and the relationship between look-up behavior and performance on vocabulary tests. The study found significantly higher scores on vocabulary production and recognition tests, and higher scores for words annotated with pictures and text than plain video + text or text only, and a correlation between looking up a certain annotation type and using this type as the retrieval cue for remembering words. The studies suggest a positive effect on incidental learning of the vocabulary in the multimedia learning environment.

With regard to the effects of L2 processing experience, Haynes and Carr (1990) investigated visual processing among three groups of college students: experienced and less experienced Taiwanese learners of English in Taiwan, as well as a group of native English speakers in lexical decision tasks which included real English words, pseudo-English words and nonwords. They found that while all groups performed best on the real word condition, a clear contrast existed between native and non-native

participants for the pseudo-word condition. The nonnative speakers' performance declined considerably when processing pseudo-words. These results indicated, among other things, that visual processing efficiency is determined by the degree of learner experience. Both the degree of orthographic experience and the learner's sensitivity to orthographic regularity play an important role in word recognition.

Other studies (Adams, 1990; Barker et al., 1992; and Stanovich, 1991) have also noted that two specific dimensions of linguistic knowledge: orthographic and phonological, independently influence word recognition.

With regard to the effects of L1 processing experience, Koda (1996) points out that cross-linguistic comparisons of word recognition processes have, in fact, provided important empirical evidence that different writing systems do require qualitatively different processing procedures. In the L2 context, it has been widely recognized that L1 skills are transferred to L2 processing even when the L1 and L2 are typologically unrelated.

Hayes (1988) investigated processing strategies adopted by native Chinese and L2 learners of Chinese in a lexical decision task. Through error analyses, Hayes' result indicated that native Chinese made more phonological errors than other types, such as graphic errors, whereas L2 learners of Chinese whose native language is English made both phonological and graphic errors, suggesting differences in processing strategies adopted by native Chinese and L2 learners of Chinese. Furthermore, Hayes' study also revealed that due to their relative inexperience in processing Chinese orthography, L2 learners used mixed and inconsistent strategies, which resulted in a higher rate of graphic errors. The implication of this study is that the effects of L2 processing experience on word recognition can be both positive and negative depending on L2 exposure.

Grainns (1992) conducted a study on lexical decision tasks under two forced conditions with ESL learners of Arabic (non-Roman alphabetic script) and Chinese ("logographic" script). The findings suggest that both groups performed better when orthographic, rather than phonological, information was available. However, when orthographic cues were not used, the performance of Chinese participants declined far more sharply than that of Arabic learners, suggesting that (a) the use of phonological

and orthographic cues varies widely among ESL learners with diverse L1 backgrounds; (b) alphabetic L1 readers rely on phonological information much more than logographic L1 readers. The findings provide further support for L1 orthographic influence on L2 word recognition. In Koda's (1990) experiment, she found that when phonological information is visually inaccessible, the performance of alphabetic L1 language learners (Arabic and Spanish) is seriously impaired. Phonological inaccessibility, however, has no effect on logographic L1 learners (Japanese).

Although the above-mentioned studies have provided important empirical evidence on both multimedia learning and L2 word recognition, none of them have focused on L2 logographic word/character recognition in a multimedia environment. It is the intention of the present study to examine the psycholinguistic principles of Chinese character recognition with varied multimedia presentations.

### **3. Hypotheses and Questions**

The present research is concerned with three issues: (a) a generative theory of multimedia learning and its effects on character recognition; (b) the effects of L2 processing experience on L2 learners of an alphabetic language background; and (c) possible L1 orthographic transfer in character recognition under different multimedia presentation conditions.

With regard to Chinese character learning, the GTML predicts that students are more likely to learn Chinese characters when the target word/characters are presented with multi-modal computer information such as verbal and visual cues, animation, and sound, than when they are presented with only one mode or none. The first question to be investigated is based on the idea that learners can establish verbal and visual retrieval cues when the relevant information about the characters is presented in both verbal and visual forms. It is expected that participants' recall of characters will be varied when the presentational information is manipulated to provide learners with the different degrees of saliency on orthography and on verbal and visual information.

The second question to be investigated is based on the theory of L2 processing experience effects (Koda, 1996), which predicts that relatively more experience in L2 orthographic processing and a learner's sensitivity to orthographic regularity will result

in better performance in word recognition. It is expected that participants' recall of characters is better as the proficiency level gets higher regardless of types of orthographic, visual, and verbal information provided for the target characters. The third question is related to the theory of L1 processing experience effects (Koda, 1996), which predicts that L1 orthographic experience has a long lasting impact on L2 processing procedures. It is expected that learners' L1 English processing strategies will interact with other factors in L2 character recognition processes and L1 transfer will occur, especially with those whose L2 language exposure is limited.

#### **4. Methodology**

##### **4.1 Participants**

One hundred twenty university students were selected from four summer intensive programs (Princeton in Beijing, the Duke China Program, Columbia Summer Chinese Program, and Associated Colleges in China) in Beijing to participate in this study. All four programs are sponsored and administered by US universities or colleges, and administer a placement test at the beginning of the program to determine learners' proficiency levels. The participants were all L2 learners of Chinese with English as their native or dominant language. Through questionnaires and oral interviews, participants were divided into four groups, 30 in each group, according to their placement in the program and years of prior exposure to formal Chinese language instruction. As Table 1 indicates, Group 1 participants had about one year of Chinese study and were all placed in the low intermediate level, Group 2 had about two years of language learning and were all placed in the high intermediate level, Group 3 had about three years and were all placed in the low advanced level, and finally Group 4 had about four years and were placed in the mid-advanced level<sup>2</sup>.

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<sup>2</sup> The proficiency levels of the participants were decided by participants' placement test results, and questionnaires, as well as their years of language exposure.

**Table 1.** Distribution of participants and their L2 experience

Groups	Number of Participants	Years of Chinese Language Exposure
Group 1	30	Over one year
Group 2	30	Over two years
Group 3	30	Over three years
Group 4	30	Over four years

#### 4.2 Materials and Procedures

In order to study the encoding process and the multimedia effects of Chinese characters, 36 Chinese characters were selected from three commonly seen character categories (see Appendix 1): (a) "pictographs," whose original form came from the shape of the object, e.g. 目 (eye) originally was a picture of a real eye, (b) meaning-meaning compounds, whose formation came from a combination of two meaningful characters, e.g. 女 (woman) and 子 (son) are combined into 好 (good), and (c) sound-meaning compounds, whose form consists of two parts, one part provides limited semantic information associated with the character and the other part provides some phonological information on the character<sup>3</sup>, e.g. 洪 “flood” is a combination of the semantic radical “water” and the phonetic component 共 “g8ng.”

In addition to the control on character type, the number of strokes in each character was controlled to an average of 10-11 strokes per character as shown in Table 2:

**Table 2.** Types of Chinese characters used in the recall tasks

Groups \ Character	Character Types	Average No. of Strokes
Group 1	Pictographs	11.4
Group 2	Meaning compounds	10.6
Group 3	Sound-meaning compounds	11.2

In order to exclude the factor of variations in frequency of occurrence, the characters were rated by experienced Chinese instructors from four institutions as known or unknown, and frequently occurring or not frequently occurring in beginning level textbooks in the US. Ninety-two percent of the target characters were rated as unknown or not frequently occurring in these textbooks.

<sup>3</sup> The information provided by the semantic and phonetic components of a character is oftentimes partial and indirect due to changes over history.

Three types of multimedia formats were designed for three processing/presentation conditions. The manipulation of the multimedia presentations came from two dimensions: one is the control of orthographic information provided by the presentation; the other is the control of media modes, which provide verbal and visual information.

In regard to the control of orthographic information, each presentation focused on one or two aspects of the Chinese orthography. Presentation 1 provided the external phonological and semantic information in the format of Pinyin<sup>4</sup> and English translation for the target character. For example, the character 好(h3o) is presented on the computer screen with its pronunciation in Pinyin “h3o” and English meaning “good.” Presentation 2 focused on the stroke information and its conventional writing order in addition to the phonological and semantic information. And Presentation 3 added graphic and radical information, including etymology and some orthographic rules, in addition to the phonetic and semantic information. For convenience of description, the three types of presentations will be called the Pinyin presentation, the stroke presentation, and the radical presentation respectively.

With the control of media modes and display time, each presentation employed two or three media types and modes to present target characters. In the Pinyin presentation, a sound playback system and text display mode were used. In the stroke presentation, animation of stroke sequences was displayed stroke by stroke on the computer screen along with the sound and text display. In the radical presentation, the animated pictures or video clips indicating the character origins and their semantic and phonetic components were displayed on the computer screen in addition to the external semantic and phonetic information of the target character. The display time for each character was controlled to approximately 5-8 seconds.

The present study was carried out with two major procedures. The first was to have participants fill out questionnaires which asked for information regarding participants' personal data such as age, sex, L1 background, types of Chinese language learning environment (natural or classroom), years of Chinese language exposure,

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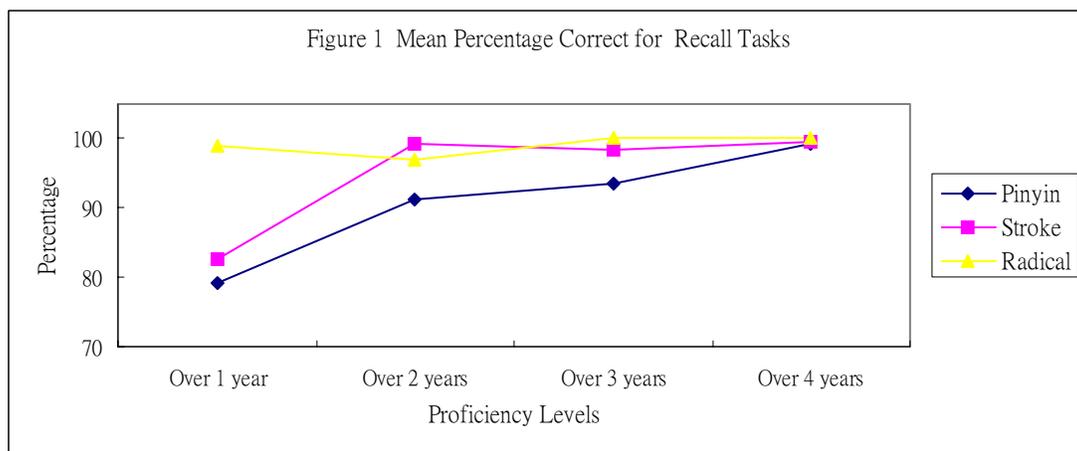
<sup>4</sup> Pinyin is an alphabetic system used to indicate the pronunciation of a character. It is the most popular of the several phonetic spelling systems used by Chinese instructors in the US to help students learn the sound system of the language and pronunciation of Chinese characters.

textbooks, weekly contact hours, and self assessment of their cognitive learning style: verbal vs. visual<sup>5</sup>. Immediately after the questionnaires were filled out, a multimedia presentation on a computer was displayed and a recall task was administered individually with the experimenter. Out of 30 participants in each proficiency group, 10 were assigned to the radical presentation, 10 to the stroke animation, and 10 to the Pinyin presentation respectively. Immediately after the presentation, the participant was given a recall test in the format of multiple choice questions. The distracters for multiple-choice tests were designed to include three types, namely, graphic, semantic, and phonetic distracters.

### 5. Results

The data of the present study were analyzed quantitatively and qualitatively. Using the tabulation of mean percentage correct on recall, the results of the performance across four levels on three presentational conditions are reported below. Errors found in the three tasks are also tabulated and analyzed.

#### 5.1 Analysis of the Mean Correct Recall on Three Presentations



**Figure 1.** Mean Percentage Correct for Recall Tasks

As Figure 1 indicates, participants’ performance is significantly affected by the presentational mode (1, 2 or 3) at lower proficiency levels but not at higher proficiency levels. With the radical presentation, the rate of recall by participants who had been

<sup>5</sup> The learning style information was used for a different study.

exposed to Chinese for-over 1 year is near perfect (98%), whereas with the stroke and Pinyin presentations, the mean correct is 79% and 82% respectively. The three presentations, however, do not seem to affect the participants at higher proficiency levels (over 3 to 4 years of language exposure) since they scored above 95% regardless of type of presentations. Using a Chi-square of independence test, 4 (group) x 3 (presentational condition), the analysis revealed that a significant difference between the Pinyin and radical presentation is observed on the performance of participants with over 1 or 2 years of language exposure ( $X^2=70.88$  at Level 1; and  $X^2=10.70$  at Level 2,  $df=1$ ,  $p<0.05$ ). A similar pattern of significant difference is observed between the stroke and radical presentations by participants with over 1 and 2 years of language exposure ( $X^2=56.53$  at Level 1,  $X^2=4.66$  at Level 2,  $df=1$ ,  $p<0.05$ ). With the Pinyin and stroke presentations, however, the difference is observed but not as high as other presentational modes ( $X^2=6.29$  at Level 1,  $X^2=24.62$  at Level 2,  $df=1$ ,  $p<0.05$ ). In addition, there is no significant difference in performance on all three presentations among participants with over 3 and 4 years of language exposure. All participants at higher levels had near perfect performances on all three presentational tasks, suggesting a L2 processing experience effect ( $X^2=3.8$ ,  $df=1$ ,  $p<0.05$ ).

## 5.2 Error Distribution and Error Analysis

As Figure 2 indicates, the distribution of errors on all recall tasks revealed a similar presentational effect across proficiency levels as Figure 1: with the Pinyin presentation having the highest number of errors (79), the stroke presentation being in the middle (22), and the radical presentation having the smallest number of errors (12). Clearly, the types of multimedia presentation with different focuses have different effects on recall tasks. Except for the Pinyin presentations, the error distribution was mostly skewed towards the lower proficiency levels (Levels 1 and 2)

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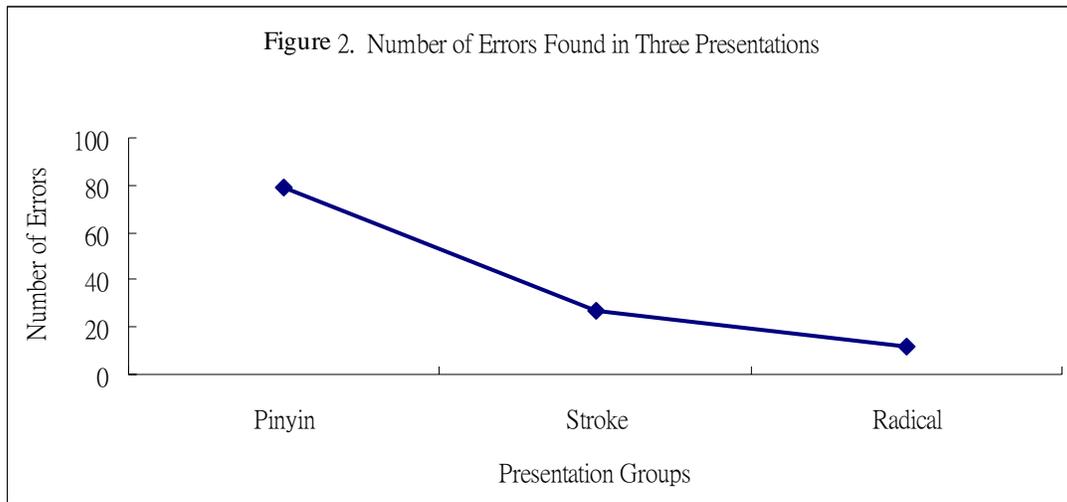


Figure 2. Number of Errors Found in Three Presentations

Table 3. Categorization of error types

Error Types	Description	Example
Phonetic errors	Error caused by the similarity in pronunciation between the two characters	拜(b4i)=掰(b1i)
Semantic errors	Error caused by semantic overlapping or semantic similarity	橘(orange)=艷(bright) <sup>6</sup>
Graphic errors	Error caused by similarity in graphic appearance between the two characters	梁(sorghum)=粢(low quality rice)
Random errors	Errors which cannot be traced to possible phonological, semantic and graphic confusion	靶(target)=諧(harmonious)

In order to further understand the distribution and sources of incorrect recalls on target characters, all errors were analyzed and categorized. Four types of errors were found, which were phonetic, semantic, graphic, and random errors as shown in Table 3 with specific examples found in the data. The distribution of errors is shown in Tables 4 and 5 according to proficiency levels and presentation types.

<sup>6</sup> The error of 橘(orange)=艷(bright) was found in all three groups and was categorized as a semantic error due to their possible indirect connection: 橘 means orange, the fruit or the bright color orange.

**Table 4.** Distribution of error types according to presentation types

Presentation Type	Number of types	Names of Error Type
Pinyin Presentation	4	Phonetic, semantic, graphic and random
Stroke Presentation	2	Semantic, graphic
Radical Presentation	2	Semantic, graphic

**Table 5.** Distribution of errors according to proficiency levels

Proficiency Levels	Pinyin Presentation	Stroke Presentation	Radical Presentation
Over 1 year	54%	83%	93%
Over 2 years	36%	2%	3%
Over 3 years	18%	3%	2%
Over 4 years	12%	2%	2%

Both Tables 4 and 5 indicate that the Pinyin presentation resulted in the largest number of incorrect recalls of characters (77), and errors ranged from phonetic, semantic and graphic to random ones. The stroke presentation, in turn, has significantly fewer errors (22) and only two types of errors, and the radical presentation falls in the category of least errors (12), with errors limited to the two types. The errors found in the stroke and radical presentations were limited to semantic and graphic ones. Both phonetic and random errors were absent in the recall tasks for the stroke and radical presentations. In addition, all four types of errors found with the Pinyin presentations were distributed across all proficiency levels, 54%, 36%, 18%, and 12% respectively, whereas the two types of errors associated with the stroke and radical presentations were only limited to the beginning level, with 85% for the stroke group and 93% for the radical group.

## 6. Discussion

The implications of the present study will be discussed in the order of (a) multimedia learning effects on Chinese character recognition; (b) L2 processing experience effects on Chinese character recognition; and (c) L1 processing experience, specifically orthographic experience, effects on Chinese character recognition.

### 6.1 Multimedia Effects on Chinese Character Recognition

One of the issues that the present study set out to investigate was whether L2

learners of an alphabetic language background will actively extract verbal and visual information from L2 multimedia presentations and integrate it in memory for Chinese character processing (Kazma, 1991). The result of well above chance performance across all proficiency levels and with all three presentations (over 75% for the beginning level and over 90% for upper levels) seems to demonstrate a positive effect of multimedia cues on word recognition. Such a result is consistent with a generative theory of multimedia learning proposed by Mayer (1997). When a character is presented with different types of multimedia presentation, learners actively select relevant verbal and visual information, organize the information into coherent mental representations, and integrate these newly constructed visual and verbal representations with one another. The data of the present study further demonstrate that in addition to alphabetic L2 languages such as English, visual and verbal cues in a logographic language can have the same effects for retrieving stored information from memory in character learning.

The present study extends the generative theory by demonstrating that multimedia effects work differently on learners with different linguistic information. As is indicated in the results, regardless of character types, (pictographic, ideographic, or sound-meaning compounds), verbal and visual radical-oriented cues seem to be more effective for character recall than the stroke-oriented cues, which are in turn more effective than the Pinyin presentation. Furthermore, the presentational effects of radicals and strokes are more obvious on L2 learners with limited L2 language exposure. One possible explanation is the dual knowledge hypothesis of Koda (1996). It is claimed that while alphabetic language users retrieve words from linguistic memory, logographic language users retrieve words from both linguistic and non-linguistic (visual-special cues such as shapes of characters) memories (Hayashi et al., 1985; Sasanuma, 1975, 1984). The theory further predicts that logographic language processing requires both linguistic and nonlinguistic knowledge. Reading Chinese thus entails a processing mechanism unique to the Chinese orthographic system. In addition to regular verbal and visual cues indicating linguistic features, such as sound and meaning of a word, it is possible that animated radicals and stroke provide visual and graphic cues unique to the Chinese writing system and that learners organize these cues into mental representations for memory. The recall performances on both radical and strokes presentations are

naturally better than the Pinyin presentations. The findings of the present study not only provide evidence in support of the dual knowledge hypothesis but also further pinpoint the crucial factors that instructors can use to help alphabetic L2 learners switch from one processing system to another.

## 6.2 L2 Processing Experience Effects on Character Recognition

The results of the recall rate and error analysis in the present study also reveal that the performance of L2 learners with longer language exposure and at higher proficiency levels is not affected by the manipulation of media types and orthographic information in presentations. This is seen in the near perfect performance on all three tasks and the limited error types (2 types) and numbers (around 3%) by participants mostly at levels 3 and 4. With data from L2 Chinese, the present study is consistent with findings found by Haynes et al (1990); Koda (1996); and Segalowitz and Segalowitz (1993). These empirical studies claim that L2 processing efficiency is the by-product of increased L2 linguistic knowledge and processing experience. In the case of Chinese characters, it has been found by Chinese scholars that knowledge of the orthographic system—such as component formation of characters and stroke order—is especially crucial for processing and retrieving characters (Huang, 2001, Cui, 2000). When L2 learners engaged in longer Chinese study, more knowledge would be gained about the Chinese orthographic system. Consequently, improvements will be observed in Chinese processing skills.

In addition to explaining the data observed in Levels 3 and 4, the processing efficiency theory can help account for the presentational effects observed in three recall tasks. Empirical studies by Adams, 1990; Barker et al., 1992; and Stanovich, 1991 have demonstrated that two specific dimensions of linguistic knowledge, orthographic and phonological, independently influence word recognition. As is indicated in the results of the present study, while the performance on the radical presentation was above 90% across all four proficiency levels, the performance on the Pinyin presentation only achieved above 70%. In addition, the errors found with the Pinyin group cover all four types of errors whose sources are from both L1 and L2 (a detailed analysis is provided in the next section), whereas the errors found with the radical and stroke groups were

mainly from L2 learning processes, such as overgeneralization of semantic and graphic rules as in 艳(y4n, bright)=橘(j), orange); 靶(b3, target)=堡(b3o, fort); 蕊(ru#, flower bud)=芯(x\$n, [candle] wick); and 粲(c4n, bright)=粲(z!, low quality rice). Such findings on the same characters extends the claims from the above mentioned empirical studies in that Pinyin and radicals along with strokes can independently and effectively influence Chinese character recognition. Based the findings, an order of presentational effects can be arrived at from the most effective to less effective for character recognition:

radical/phonetic/semantic > stroke/phonetic/semantic > phonetic/semantic. Both L2 processing strategies and adequate L2 character presentations will affect the learning of Chinese characters.

### 6.3 L1 Orthographic Effects

Analysis of errors found in the three tasks also indicates that the L1 processing experience effect was most evident at the beginning and intermediate stage and with the Pinyin presentation. As the results in the present study indicate, the recall errors were mostly committed by beginning level participants (above 80%).As for the errors found in three presentation groups, the Pinyin group made the most recall errors (79). As was mentioned above, the Pinyin group covered all four types of identifiable errors, namely, phonological, semantic, graphic, and random errors. For example, the phonological errors were found with characters which share the same or similar pronunciation but are different in meaning and graphic shapes, e.g. 渡(d\*, to cross [a river], or to spend [time])=鹿(l\*, deer) ; 拜(b4i, to worship) = 掰(b1i, to pull apart [by hand]); 龟(gu! turtle) = 诡(gu#, tricky, cunning). Random errors included the association of those characters which do not seem to have any linguistic or nonlinguistic connection with each other, e.g. 岔(ch4, fork road) = 武(w&, military) ; 忿(f=n, anger)= 谐(xi0, harmonious); 靶(b3, target) = 谐(xi0, harmonious); 痨(l2o, long-term disease) = 围(w0i, surround). It is interesting to note that these errors were not found in the radical and stroke groups at any level.

A further error analysis indicated that all errors belong to two major types: one

being transfer errors, and the other being developmental errors. Most of phonological errors were L1 transfer errors associated with incorrect application of phonological rules on a character without considering its orthographic information. The random errors are both L1 transfer and developmental as a result of L1 influence and uncertainty about the L2 orthographic system. The semantic and graphic errors were apparently errors made while applying different L2 orthographic rules in Chinese and are therefore developmental errors. Clearly L1 processing experience effects were found in the present study and influenced character recognition. At the same time, L1 processing effects are interacting with L2 processing effects. The L1 and L2 interaction resulted in the absence of phonological and random errors in the radical and stroke tasks but in their presence in the Pinyin task. It is highly possible that relevant and salient orthographic cues (the graphic, semantic, and phonological), on the one hand, have contributed to semantic and graphic errors because of overgeneralization, and on the other hand, the salient radical and stroke presentations might have helped learners overcome or suppress the L1-based processing mechanism.

Findings on L1 processing effects support claims by Hayes that L2 learners of Chinese adopt different processing strategies in character recognition. From a logographic language point of view, the results also provide support for the findings of Grairns (1992); Green and Meara (1987); Koda (1990); and Ryan and Meara (1991) in that L2 learners utilize, to varying extents, L1-based processing devices during L2 word recognition. L2 learners from varying L1 orthographic backgrounds utilize distinct L2 processing strategies.

In summary, the present study has important theoretical and pedagogical implications in both generative theory of multimedia learning and L2 word recognition research. First, using the non-alphabetic L2 data, the findings of the present study provide evidence in support of the claim by Mayer (1997) that when a learner can construct and coordinate visual and verbal representations of the same materials, meaningful learning is enhanced. Second, through three different types of multimedia manipulation of orthographic information, the present study found that three critical factors will contribute to performance improvement in L2 Chinese acquisition: (a) increased exposure to the L2 and L2 processing strategies which are different from the

L1, (b) increased overall L2 linguistic knowledge, specifically orthographic knowledge on Chinese radicals and strokes, and finally (c) metalinguistic awareness on the part of L2 learners, i.e. sensitivity to orthographic regularity. Finally, the variable presentational effects of the three tasks further reveal that the relevant and salient information on internal Chinese orthographic regularity is extremely crucial for L2 Chinese learners of alphabetic backgrounds, especially for learners at the beginning stage. Systematic and conscious efforts should be made by instructors to incorporate into their teaching materials multimedia information on analysis of phonetic and semantic components of each character, etymological information, stroke types and order, and detailed semantic and phonological explanations. These types of information will help provide L2 learners with two types of information, linguistic and non-linguistic to construct “referential connections” between two forms of mental representational systems and further help establish a better L2-based processing system.

**Appendix 1. Chinese Characters Used in the Study**

Types of characters	Examples
Group 1: Pictographs	雲(12) 魚(12) 象(12) 叟(10) 鳥(10) 龜(13) 舟(6) 鹿(11) 燕(16) 豕(7) 網(6) 森(12)
Group 2: Meaning-meaning compounds	武(8) 孛(11) 蕊(15) 岔(7) 塵(14) 泉(9) 辦(12) 艷(10) 棗(12) 屎(9) 姆(10) 姥(10)
Group 3: Sound-meaning compound	鐘(9) 靶(13) 堡(12) 煉(13) 圍(7) 渡(12) 禪(12) 舫(10) 癆(12) 橙(15) 諧(11) 忿(9)

## Appendix 2. Examples of Three Presentations

bǎ  
靶  
target

革  
leather

巴  
bā

stop continue previous next

The Radical Presentation (1)

叟 sǒu old man

stop continue previous next

The Pinyin Presentation

shǐ  
豕  
boar, pig

stop continue previous next

The Stroke Presentation



The Radical Presentation (2)

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## 多媒體漢字呈現與漢字習得

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本文旨在通過漢字學習的心理實驗，進一步探討多媒體漢字呈現及學習者的語言文字背景對第二語言學習者漢字辨識及習得的影響。實驗選擇一百二十名學過一年至四年華語的美國大學生作為被試，其母語背景均為英語。實驗採用三種電腦多媒體形式分別向三組不同程度的被試呈現 36 個漢字的信息。第一種呈現突出漢字的部件組合，第二組突出漢字的筆順排列，第三種突出漢字的發音。在多媒體漢字呈現結束後，實驗隨即對被試進行 36 個漢字的記憶測驗。實驗結果証實，在漢字學習上，多媒體漢字部件的呈現最為有效，其次是筆順，最後是發音。此外，本實驗還發現除了電腦多媒體效應外，漢字學習成功的關鍵還與三個因素有關：第一、華語學習者能否有意識地使用與母語不同的語言策略；第二、所學目標語言的時間長短；最後，對所學語言的書寫系統之規律性的敏感度。

關鍵詞：多媒體、漢字習得、部件、筆順、拼音呈現、語言策略、書寫系統的規律性