Evaluating the Critical Period Influence on the Development of Semantic Radicals Awareness and Lexical Tones Awareness in Chinese Character Recognition

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Abstract: The present study adopts the priming word-judging paradigm to investigate whether the critical period will influence radical and lexical tone awareness during the bilinguals' Chinese character recognition. Two types of bilinguals (simultaneous and sequential bilinguals) will be recruited as participants in the present study. The different features between these two types of participants are used to test the influence of the critical period. Through a Chinese character decision task experiment, we hypothesis that the critical period will influence the semantic radical and lexical tone awareness while processing the Chinese characters of bilinguals. In addition, this study will provide some advice to learning Chinese characters in second language acquisition.

Keywords: critical period, Chinese character recognition, semantic radical, lexical tone, bilinguals

1. Introduction

This paper will discuss the influence of the critical period on semantic radical and lexical tone awareness in Chinese character recognition. Lenneberg proposed the Critical Period Hypothesis (CPH) to indicate that the optimal age for language acquisition is after two years old and before puberty (generally speaking, 10 to 12 years old)[1]. Although the Critical Period Hypothesis research in language acquisition has existed for nearly 50 years, most studies only aimed at the CPH in learning English as a second language (L2) [2]. However, Chinese has an entirely different language and writing system from English as a pictographic language, which might lead to the other way that individuals recognize Chinese characters when learning it as a second language [3]. Thus, we come up with the question: how will the critical period affect individuals' Chinese character recognition?

To make this question more specific and research worthy, we will focus on individuals' semantic radical and lexical tone awareness on processing Chinese characters when Chinese is acquired as a second language. The semantic radicals and lexical tone are significant compounds of Chinese characters, and both provide semantic clues when individuals recognize Chinese characters. Few studies investigate these two compounds together in processing Chinese characters, considering the influence of the critical period. Thus, this current study aims to take a step further in the research on CPH and word recognition by separately evaluating the impact of the critical period on individuals' semantic radical and lexical tones awareness in Chinese character recognition, under the background of Chinese being acquired as a second language.

2. Literature Review

Although the theoretical discussion and empirical research of age factors on second language acquisition have existed for nearly 50 years, the domestic study on Chinese as second language acquisition is still inadequate, and the existing literature mainly illustrates the theories and achievements of English as second language acquisition [2]. In addition, word recognition is the ability to comprehend and read words by correlating their pronunciation and written form[4]. Therefore, word recognition lays a strong foundation for an individual's second language acquisition (SLA) both in the alphabetical language (e.g., English) and pictographic language (e.g., Chinese).

Chinese is a pictorial language that does not have an "alphabet." The majority of Chinese words are made up of Chinese characters. A single Chinese character can be used to form a word; that is, recognizing Chinese characters can be viewed as a specific part of recognizing Chinese words. Therefore, this present study focuses on exploring how the critical period would affect Chinese character recognition in Chinese as second language acquisition.

2.1. The definition of the CPH in L1

The concept of the "critical phase" was first introduced in the field of biology. It refers to a period of an organism's lifespan or development during which the environment plays an essential and optimal role in the individual's ability to learn a particular behaviour. Penfield and Robert were the scholars who initially introduced the "critical time" concept in first language acquisition[5]. They discovered that children's language acquisition abilities were closely linked to their brain development and that the optimal age for language acquisition was established at ten years old. Lenneberg then developed the "Critical Period Hypothesis" (CPH) and popularized it[1]. According to Lenneberg's statement for the critical period hypothesis, there were physiological restrictions at the time when a first language could be mastered. After two years of age and before puberty (generally speaking 10 to 12 years old), both cerebral hemispheres of a child's brain are involved in language learning, making language understanding and production much more accessible.

2.2. CPH in L2 Acquisition

There exist three different hypotheses about the relationship between the age of acquisition (AoA) of a second language and its ultimate achievement, according to the Critical Period Hypothesis in first language acquisition. First, there is a significant negative association between the AOA of learning L2 and L2 learning efficiency throughout the critical period. Second, when the beginning age reaches the critical period, the language acquisition ability of late learners experiences an abrupt decline. Third, the late learners' final L2 accomplishment level will not be comparable to native speakers after the critical time. Many researchers have presented evidence to support these hypotheses in the areas of psychology, cognitive behaviours, and neurolinguistics. For example,

Johnson and Newport's research in English grammar demonstrated that the participants' performance on grammar judging tasks was significantly decreased with the increase of age[6]. According to Weber-Fox and Neville, the later learners began to study a second language (L2), the slower their semantic processing became[7].

2.3. Critical Period in Semantic Radical and Lexical Tone in Chinese Character Processing

Recent studies conducted by scholars also indicated that the critical period indeed impacts individuals' Chinese character recognition in all aspects. For example, Chai's empirical study showed that the starting age significantly affected Chinese vocabulary acquisition for pre-puberty beginners[2]. Zhang, Zhou and Cao's study found a significant difference between 4-years-olds and 5 - and 6-year-olds in their ability to recognize the complexity of Chinese characters[8]. Still, there was no discernible difference between the 5-year-old and 6-year-old groups. Therefore, Li indicated that age 5 is a critical period for children to develop their Chinese character processing ability.

However, Chinese and English, after all, belong to two different language systems; English is a form (hypotaxis) attribute that is rather than the parataxis attribute of the phonetic language system. Chinese is a meaning attribute language more vital than the semantic language system, and Chinese character acquisition is a language module unique to learning Chinese. Therefore, the conclusions and evidence of research on alphabetic language (e.g., English) are not necessarily entirely consistent with Chinese acquisition as a second language. Since Chinese has many features distinctly different from English, individuals might process and recognize these two languages differently. Although both English words and Chinese characters use phonological coding characters, graphemic and semantic information significantly impact Chinese character recognition. In contrast to alphabetic languages, over 80% of Chinese characters are semantic–phonetic compound characters that include sub-morphemic components, namely phonetic and semantic radicals[9]. Each compound character contains a phonetic and a semantic radical [10][11]. Phonetic radicals give clues to the compound characters' pronunciations, whereas the semantic category of compound characters is revealed via semantic radicals. (see Figure 1). In addition, the lexical tone is another significant component in Chinese characters. Mandarin has four lexical tones. It will be different in meaning when they combine with the same syllable, respectively. For example, ma1 (mother), ma2 (hemp), ma3 (horse), ma4 (scold) (see Table 1). Lu said that tone contours were considered phonemic in Mandarin because they constituted distinctive features[12]. In summary, both semantic radical and lexical tone provide semantic clues to Chinese characters.
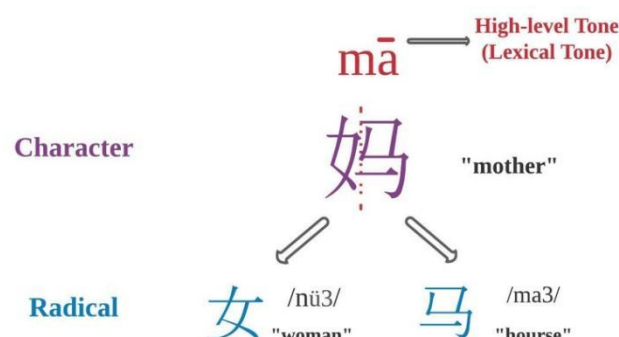

Figure 1: Example of Compound Chinese Character

Table 1: Examples of Lexical Tone in Chinese Compound Characters

Character	Pinyin	Lexical tone	Meaning
妈	Ma	High-level tone (ˉ)	Mother
麻	Ma	Rising tone (´)	Hemp
马	Ma	Low-dipping tone (ˇ)	Horse
骂	Ma	Falling tone (`)	Scold

Although some scholars have studied the influence of CPH on semantic radical awareness in Chinese character processing[8], the findings were revealed under the background of L1 Chinese acquisition. However, we found no strong evidence that the critical period influences both semantical radical and lexical tone awareness, specifically during the acquisition of Chinese as a second language. Thus, considering the significant role of semantic radicals and lexical tone in Chinese character processing. In this current study, we aim to evaluate the influence of the critical period on the development of semantic radicals and lexical tone awareness in Chinese character processing, thus, to testify the impact of CPH on character recognition when Chinese is acquired as a second language. Therefore, a specific research question was designed to guide this current study: *How does the critical period impact semantic radical and lexical tone awareness in Chinese characters Recognition?*

3. Proposed Study

3.1. Alternatives

The critical period will influence both the semantic radical and lexical tone awareness during the Chinese characters' processing of L2 learners. Or the critical period will influence only the semantic radical or/and lexical tone awareness at the same time during the Chinese character processing of L2 learners.

3.2. Logic

We will adopt the priming word-judging paradigm, where a target one will follow a prime character, and participants are required to judge whether the target is an actual character or not. By controlling the semantic category of characters, the transparency (the semantic category is similar to the meaning of semantic radical) of character categorical meaning can influence the function of semantic radicals in word recognition[13].

The target and the prime can have the same semantic radical, the same lexical tone or/and the same semantic category. If the same semantic radical between the prime and the target facilitate the participants' reaction time which is the duration from the start the participants see the word to the moment, they make the judgment. It demonstrates that the participants will own the semantic awareness, so will the lexical tone.

4. Methods

4.1. Participants

There are a total of 60 participants in two participant groups in this study; each group consists of 30 participants, aged from 18 to 25, who live in America and are all right-handed. All participants have

no problems with their brains, hearing, vision or corrected vision. In order to figure out the influence of the critical period, we will divide the participants into two groups. They are the simultaneous bilinguals who have learned Chinese and English since birth and the sequential bilinguals who have learned Chinese as their second language since 12 years old. In the present study, the participants need to fill out a questionnaire to investigate the characteristics of participants. (i.e., How long they have learned Chinese and the ages they started to learn Chinese). The age of starting to learn Chinese characters of the simultaneous bilinguals is the same.

4.2. Materials

2 (2 groups of participants) * 5 (5 stimulus conditions) design. The examples of stimuli are as shown below (Table 2),

Table 2. Example of Stimuli for five Experimental Conditions

condition	Prime	target	Semantic Radical(R) (prime/target)	Semantic Radical meaning (prime/target)	Lexical tone. (T) (prime/target)	Semantic category (S)
R-T-S- (baseline)	饱, "bao3" "full"	明 "ming2" "bright"	饣/日	Food/Sun	3/2	Full/Bright
R-T+S+	污, "wu1" "dirty"	脏, "zang1" "dirty"	氵/月	Water/Body	1/1	Dirty/Dirty
R-T+S-	打, "da3" "beat"	洗, "xi3", "wash"	扌/氵	Hand/Water	3/3	Beat/Wash
R+T-S+	扯, "che3" "pull"	拉, "la1" "pull"	扌/扌	Hand/Hand	3/1	Pull/Pull
R+T-S-	河, "he2" "river"	治, "zhi4" "treat"	氵/氵	Water/Water	2/4	River/Treat

For every condition, "R" represents semantic radical, "T" represents the lexical tone, and "S" represents the semantic category of character, "+" represents the "accordance" between the prime and target, "-" represents "disaccord" between the prime and the target. The R-T-S- provides a baseline to test the effect of other types of conditions. The stimuli are all left-right structure characters. There will be six trials for every condition. To avoid the participants finding out the regularity of the experiment, 30 fillers that do not meet any of the experimental conditions will be set at the present study. Half of their target characters are pseudo characters. So, there are 60 trials in total. The experiment data will be collected online, and the experiment stimuli will be presented by a link from Ibex Farm[14], a psychological experiment platform.

4.3. Procedures

The participants will be required to sit in a quiet room and promise to do this experiment without any distractions and interruptions before finishing. Before doing the experiment, the participants need to read the introduction and practice several trials to be familiar with the experiment. The experiment is designed according to Zhou & Marslen-Wilson[15]. When the experiment begins, a red cross will appear on the centre of the screen for 300ms to make participants concentrate on the screen. After the red cross disappears, a prime character will be shown on the screen. The prime

will be presented for 200ms, and the target is shown for 400ms. Participants need to judge whether the target is a true or a wrong character by pressing the key on the keyboard.

4.4. Analysis

The measurement is RT. According to Feldman and Siok [13], we eliminate the RT that is more than extreme 3 SD and the incorrect responses. Two-way ANOVA is used for data analysis. A linear mixed effect model is built by using the lme4 package in R [16]. The participant conditions and stimulus conditions are fixed effects, and the participants and the terms are the random effects. The post-hoc test needs to be used to test the RT differences between the simultaneous bilinguals and sequential bilinguals.

5. Results and Discussion

The difference between simultaneous bilinguals and sequential bilinguals demonstrates the critical period influence. So, hypotheses are as follows:

1) If the RT difference between R+T-S+ and R-T-S- of simultaneous bilinguals is significantly longer or shorter than that of sequential bilinguals, we will suppose that the critical period will influence the semantic radical awareness when L2 learners process a semantic transparent character. If the RT difference between R+T-S- and R-T-S- of simultaneous bilinguals is significantly shorter or longer than that of sequential bilinguals, we will suppose that the critical period will influence the semantic radical awareness when L2 learners process a semantic non-transparent character.

2) If the RT difference between R-T+S+ and R-T-S- of simultaneous bilinguals or is significantly longer or shorter than that of sequential bilinguals, we will suppose that the critical period will influence the lexical tone awareness of L2 learners when they process a semantic transparent character. If the RT between R-T+S- and R-T-S- of simultaneous bilinguals is significantly shorter or more extended than that of sequential bilinguals, we will suppose that the critical period will influence the lexical tone awareness of participants to give an inhibition to L2 learners when they process a semantic non-transparent character.

6. Conclusion

6.1. Implications

1) This current study provides evidence that the critical period would influence Chinese character recognition when Chinese is acquired as a second language, so it can be used in researching origins in second language learning.
2) The present study provides valuable information for teaching young children Chinese as a second language. For example, the teachers could boost children's Chinese character learning process by emphasizing certain parts (semantic radical or lexical tone) of Chinese characters to develop their awareness of these parts.

6.2. Limitations

According to the needs of our experimental design and the limitation of Chinese characters that meet our conditions, the frequency and the radical consistency of the prime and the target cannot be taken into account, which may cause certain deviations in the experimental results.

Acknowledgement

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