Video Article

Comparing the Frequency Effect Between the Lexical Decision and Naming Tasks in Chinese

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Abstract

In psycholinguistic research, the frequency effect can be one of the indicators for eligible experimental tasks that examine the nature of lexical access. Usually, only one of those tasks is chosen to examine lexical access in a study. Using two exemplar experiments, this paper introduces an approach to include both the lexical decision task and the naming task in a study. In the first experiment, the stimuli were Chinese characters with frequency and regularity manipulated. In the second experiment, the stimuli were switched to Chinese two-character words, in which the word frequency and the regularity of the leading character were manipulated. The logic of these two exemplar experiments was to explore some important issues such as the role of phonology on recognition by comparing the frequency effect between both the tasks. The results revealed different patterns of lexical access from those reported in the alphabetic systems. The results of Experiment 1 manifested a larger frequency effect in the naming task as compared to the LDT, when the stimuli were Chinese characters. And it is noteworthy that, in Experiment 1, when the stimuli were regular Chinese characters, the frequency effect observed in the naming task was roughly equivalent to that in the LDT. However, a smaller frequency effect was shown in the naming task as compared to the LDT, when the stimuli were switched to Chinese two-character words in Experiment 2. Taking advantage of the respective demands and characteristics in both tasks, researchers can obtain a more complete and precise picture of character/word recognition.

Video Link

The video component of this article can be found at https://www.jove.com/video/53815/

Introduction

In the reading experience, higher occurrence of a word increases the speed at which it will be identified, which is known as the frequency effect in the psycholinguistic field. Manipulating the variable of word frequency in psychophysical research, people observed lower thresholds of recognizing common words[1,2]. In the late 1970s, the word frequency has been widely regarded as one of most important variables influencing word identification[3,4]. Focusing on the word frequency and involving other related variables, most theories in explaining the word recognition had been constructed and spread[5-9]. Hence if it is claimed that one task can capture the process of word recognition effectively, it should be sensitive to the changes of word frequency. In the literature of written word recognition, both the lexical decision task (LDT) and naming tasks meet this criterion and researchers usually chose one of them to probe into the underlying mechanism of recognition.

Among research about word recognition in different languages, the LDT and naming task have been the classical experimental methods that use response-time measures to understand the mental processes of reading. In the LDT, researchers measure the time of the participant's decision making about whether a written stimulus is a word or not. As for the naming task, researchers measure how long it takes for the participant to speak a written word aloud. However, either of the two tasks has its own task demands and limitations. The LDT involves a discrimination process between words and non-words/pseudo-words, and a decision-making process of the participant. The naming task requires the participant to pronounce the stimuli, and phonological information must be used to fulfill the task requirement.

Results of the two tasks in previous research manifested different frequency effects in variety of scripts. In the alphabetic systems, the LDT manifested a larger frequency effect than the naming task[3]. In opinions of Balota and Chumbley (1984), the lower-frequency words have similar orthography with the non-words/pseudo-words. Thus, it takes longer for participants to discriminate the orthographic similarities to make the accurate response, which possibly exaggerates the frequency effect in the LDT. While in the naming task, especially when stimuli are from languages of shallow orthography, participants may pronounce the word using the orthography-to-phonology (O-P) conversion rules to make a response before they truly identify it. This naming demand has been taken as evidence of possible pre-lexical phonology on recognition in alphabetic languages. Such a naming strategy is argued to undermine the frequency effect[10]. In sum, although sensitive reflections to the manipulation of word frequency can be observed in both tasks, the LDT and the naming task may capture different stages and characteristics of the recognition process. To obtain a more precise and complete view, the proper way is adopting the two tasks meanwhile and comparing the patterns of their results.

Different from the alphabetic languages, Chinese has the characteristic of deeper orthography and involves the concept of characters in addition to words. In general, a Chinese word (*e.g.*, 家人, jiā rén, family member) is composed by two characters ("家", jiā, family; "人", rén, person). Before a word is identified, the recognition process of characters within the word should be finished[11]. In light of the unique psycholinguistic characteristics, the recognition process of a character or word in Chinese is quite distinct from the word recognition in alphabetic systems. If studies combine the LDT and the naming task in the same experiment to investigate frequency effect in Chinese, interesting revelations can be shown, *e.g*., phonological activation regarding visual character/word recognition. In processing Chinese characters, the use of the naming task shows a larger frequency effect than the LDT, which implies the existence of post-lexical phonology[12, 13]. Switching the stimuli to Chinese two-character words, a reversal pattern occurs. A larger frequency effect is found in the LDT than that in the naming, suggesting the existence of pre-lexical phonology. The participant produces the oral response according to the phonological information of the component characters, before the whole word is identified[11, 14]. Moreover, results after manipulating the regularity of the characters in the stimuli can reveal valuable information about phonological processing, and help researchers make inferences about when the retrieval of phonology occurs. The following experiments showed how the researchers combined the LDT and the naming task to investigate the frequency effect of Chinese characters and words to elaborate the underlying logic.

Protocol

All subjects must give informed written consent before the administration of experimental protocols. All procedures, consent forms, and the experimental protocol were approved by the Research Ethics Committee of National Taiwan University.

1. Comparing the Frequency Effect between the Lexical Decision and Naming Tasks in Chinese Character Recognition (Experiment 1)

1. Recruit the Participants
    1. Recruit forty-four students from National Taiwan University to participate in both the LDT and the naming task. The participants must be native Chinese speakers with normal or corrected-to-normal vision, and fluent in listening, speaking, reading and writing Mandarin. All of them were right-handed.

2. Materials
    1. Select a total of 180 characters from Chinese character database of Wu and Liu (1987). Use 90 high-frequency characters and 90 low-frequency characters. According to Wu and Liu (1987), the high-frequency character is defined by the occurrence more than 100, and the low-frequency is defined by the occurrence from 1 to 15, among a total frequency of about one million in the database. Balance the important lexical characteristics (frequency, number of strokes, and/or other properties, *etc*.) of the materials chosen across conditions.
    2. Based on the phonology of the phonetic radical and the character, ensure that the characters contain three regularity types: regular, in which the phonetic radical and the character share the same pronunciation (ignoring the tones); irregular, in which there are differences between their pronunciations; and non-phonogram, in which the character cannot be defined as a phonogram.
    3. Classify each character into one of the six categories: (1) high-frequency, regular (*e.g*., 胞, bāo, compatriot) (2) high-frequency, irregular (*e.g*., 冰, bīng, ice) (3) high-frequency, non-phonogram (*e.g*., 段, duàn, section) (4) low-frequency, regular (*e.g*., 絆, bàn, stumble) (5) low-frequency, irregular (*e.g*., 妃, fēi, wife of a prince) (6) low-frequency, non- phonogram (*e.g*., 惰, duò, lazy). Each category contains 30 characters.
    4. Using TrueType (built in the Windows OS), construct 180 pseudo-characters by keeping the right radical of the characters and changing the left radical to another one. Make sure that there is no significant difference in the numbers of strokes between the characters and pseudo-characters.
        1. Start the TrueType program. When a dialog box appears, click the OK button and start the program to construct the pseudo-characters. Click the Windows-Reference in the menu, then a reference panel will show up and choose a proper font.
        2. Input one real character in the blank box of the panel and click the OK button. Two panels will appear side by side on the screen. In the right panel of constructing characters, use the tool of Free Selection button to select the left radical of this real character with a circle. Move the left radical to the left panel of constructing characters. Then the left radical of the pseudo-characters has been made.
        3. Click the Windows-Reference in the menu again, and adopt the similar procedures to select the right radical of another real character. Move the right radical to the left panel of constructing characters. Put the two radicals together and make sure the combination of those two radicals is meaningless in the lexicon. A pseudo-character has been constructed. Then save the pseudo-character in the computer.
    5. Adopt a frequency (high, low) by regularity (regular, irregular, and non-phonogram) within-subject factorial design. Set the type of task as a between-subject variable.
    6. Randomize all the items.

3. The LDT
    1. Use a standard experimental software, such as the E-Prime, to program the experiment according to software protocols.
    2. Make sure that 50% of the stimuli are characters for the "Yes response" and the others are pseudo-characters for the "No response".
    3. Ask the participants to judge whether the written stimulus appearing on the screen is a real character or not. Instruct them to respond as accurately and quickly as possible by pressing one of two keys, one is for "Yes response", and the other is for "No response". Remind all the participants to use right hand when making responses.
    4. Start each trial with an asterisk to indicate a fixation point at the center of the monitor for 500 msec, accompanied by a 100 Hz warning tone for 200 msec, followed by a blank screen appeared for 500 msec.

5. After the asterisk, show the target character, which subtends a visual arc of approximately 2 degrees, from a 70 cm viewing distance, until the computer detects the participant's key stroke, and measure the response time (RT) from the onset of the target character until a key-press response is made.
6. Set the time interval between one trial and the next with a blank screen for 1,000 msec. The computer will record the RT and accuracy rate of the participants' responses in the LDT by keyboard pressing.
7. Provide all the instruction both in written format on computer screen and verbally, and participants performed the task individually. NOTE: In the exemplar experiment 1, the task included a practice session having 20 trials with feedback. During the experiment session, participants had a rest every 36 trials. A typical session including the practice one will take a participant 25 - 30 min to complete.

2. Comparing the Frequency Effect between the Lexical Decision and Naming Tasks in Chinese Word Recognition (Experiment 2)

1. Recruit the Participants
    1. Recruit thirty-six students from National Taiwan University to participate in both the LDT and the naming task. The recruitment criterion is the same as that in Protocol 1.

2. Materials
    1. Select a total of 288 two-character words, in which half of them are real words and the other half are pseudo-words. According to Wu and Liu (1987), the high-frequency word is defined by the occurrence more than 50. Balance the important lexical characteristics (frequency, and/or other properties, *etc*.) of the materials chosen across conditions.
    2. Based on the phonology of the phonetic radical and the character, ensure that the leading character within the words contains three regularity types: regular, in which the phonetic radical and the character share the same pronunciation (ignoring the tones); irregular, in which there are differences between their pronunciations; and non-phonogram, in which the character cannot be defined as a phonogram.
    3. Control the leading characters within the real words for frequency across regularity types and make sure that the leading characters within the pseudo-words (*e.g.*, 現雀, xiàn què) are different from those in the real words.
    4. Adopt a frequency (high, low) by regularity (regular, irregular, and non-phonogram) within-subject factorial design.
    5. Classify each word into one of the six categories: (1) high-frequency, regular leading character (*e.g.*, 佈置, bù zhì, arrange) (2) high-frequency, irregular leading character (*e.g.*, 扮演, bàn yǎn, play the role) (3) high-frequency, non-phonogram leading character (*e.g.*, 博士, bò shì, doctor) (4) low-frequency, regular leading character (*e.g.*, 佈局, bù jú, distribution) (5) low-frequency, irregular leading character (*e.g.*, 扮相, bàn xiàng, actor in costume) (6) low-frequency, non-phonogram leading character (*e.g.*, 博學, bò xué, eruditely).
    6. Assign all the stimuli into two blocks, and make each block correspond to a task type. Counterbalance the order of blocks among the participants.
    7. Randomize all the trials within each block.

3. The LDT
    1. Use a standard experimental software, such as the E-Prime, to program the experiment according to software protocols.
    2. Make sure that 50% of the stimuli are words for the "Yes response" and the others are pseudo-words for the "No response".
    3. Ask the participants to judge whether the written stimulus appearing on the screen is a real word or not. Instruct them to respond as accurately and quickly as possible by pressing one of two keys, one is for "Yes response", and the other is for "No response". Remind all the participants to use right hand when making responses.
    4. Set the same requirements and arrangements as in Experiment 1, except that the stimulus on the screen is a word or pseudo-word instead of a character or pseudo-character.
    5. Provide all the instruction both in written format on computer screen and verbally, and participants performed the task individually.

4. The Naming Task
    1. Use a standard experimental software, such as the E-Prime, to program the experiment according to software protocols.
    2. Make sure that 50% of the stimuli are words for the "Yes response" and the others are pseudo-words for the "No response".
    3. Ask the participants to pronounce the written words or pseudo-words on the screen. Instruct them to make a response as accurately and quickly as possible.
    4. Set the same requirements and arrangements as in Experiment 1, except that the stimulus on the screen is a word or pseudo-word instead of a character or pseudo-character.
    5. Provide all the instruction both in written format on computer screen and verbally, and participants performed the task individually.

Representative Results

The frequency effect was observed to be robust in both the two tasks, the evidence of which was significantly shorter RT for the high-frequency characters. More importantly, a frequency by task interaction was found. Post-hoc comparisons showed a larger frequency effect in the naming task than in the LDT, which was different from those reported by the studies in the alphabetic systems.

Moreover, a regularity by frequency interaction was found on RTs and error percentages. A regularity effect was observed for low-frequency characters in the naming task. Participants made oral responses significantly faster and more accurately for low-frequency regular phonograms as compared to low-frequency irregular phonograms and low-frequency non-phonograms.

The results of Experiment 1 are shown in **Table 1** and **Figure 1**.

task	High-frequency			Low-frequency		
	regular	irregular	Non-phonogram	regular	irregular	Non-phonogram
naming	450	451	443	538	678	639
	(0.02)	(0.03)	(0.01)	(0.05)	(0.21)	(0.16)
LDT	446	455	454	544	555	570
	(0.02)	(0.04)	(0.02)	(0.11)	(0.14)	(0.12)

Table 1: Results of Experiment 1, Averages of RTs (in msec) and Error rates (in parentheses) as a Function of Frequency and Regularity in Two Tasks.

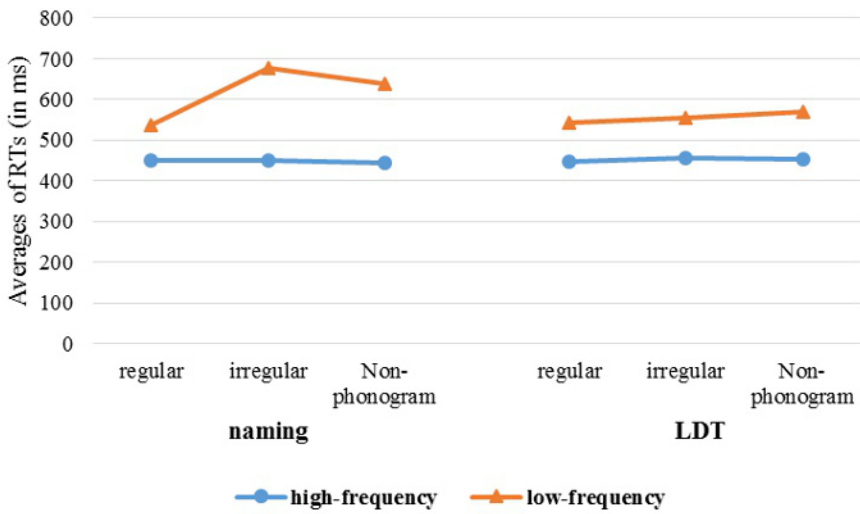

Figure 1. Results of Experiment 1, Averages of RTs (in msec) as a Function of Frequency and Regularity in Two Tasks.

Participants performed faster and more accurately for high-frequency characters, *i.e.*, the frequency effect. The naming task manifested a larger frequency effect than that in the LDT. In the naming task, a regularity effect was observed, which indicated that participants responded slower to the low-frequency irregular characters and non-phonograms.

In Experiment 2, the frequency effect was observed in both the two tasks. Participants performed faster and more accurately for high-frequency words. It is noteworthy that a frequency by task interaction was found on RTs. Post-hoc comparisons showed a larger frequency effect for processing words in the LDT than in the naming task, which was the opposite pattern from that reported by Experiment 1 with characters as stimuli. Moreover, there was no significant regularity effect observed in the LDT or the naming task.

The results of Experiment 2 are shown in **Table 2** and **Figure 2**.

task	High-frequency			Low-frequency		
	regular	irregular	Non-phonogram	regular	irregular	Non-phonogram
	LC	LC	LC	LC	LC	LC
naming	520	507	517	561	564	541
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
LDT	479	476	482	553 (0.07)	569	561
	(0.01)	(0.00)	(0.01)	(0.07)	(0.13)	(0.05)
Note. LC = leading character.						

Table 2: Results of Experiment 2, Averages of RTs (in msec) and Error Rates (in parentheses) as a Function of Word Frequency and Regularity of Leading Character in Two Tasks.

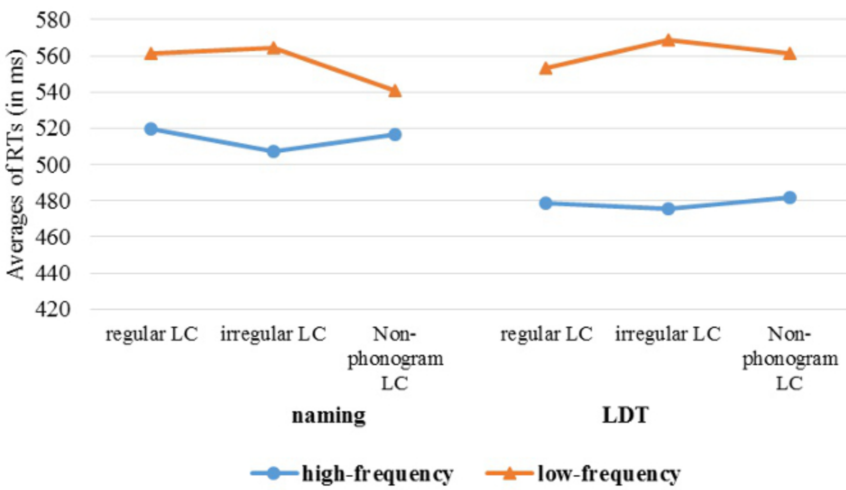

Figure 2. Results of Experiment 2, Averages of RTs (in msec) as a Function of Word Frequency and Regularity of Leading Character in Two Tasks.

Participants performed faster and more accurately for high-frequency words, *i.e.*, the frequency effect. The LDT manifested a larger frequency effect than that in the naming task. There was no significant regularity effect observed in the LDT or the naming task.

Discussion

This study demonstrates that the differences in frequency effects between the two tasks can help to elucidate the role of phonology on recognition such as pre-lexical and post-lexical phonology. In Chinese character recognition (Experiment 1), the phonology process may be post-lexical with a larger frequency effect in the naming task than in the LDT. This finding is different from the results reported in alphabetic languages. In Chinese word recognition (Experiment 2), a smaller frequency effect in the naming task may be due to pre-lexical phonology, which relates to the sub-word character process during naming.

In visual word recognition, if the naming task involves the sub-lexical phonological process before lexical access in English[12], participants might pronounce a word by using the orthography-to-phonology conversion rules that would not be modulated by frequency, and thus adopting this strategy may dilute the observation of the frequency effect. The expected results should be a smaller frequency effect in the naming task as compared to the LDT.

However, it is not the case in Chinese. The results of Experiment 1 manifested a larger frequency effect in the naming task as compared to the LDT. A possible inference is that pre-lexical phonology may not occur in Chinese. Retrieving the phonology of a Chinese character may occur after the lexical identification process. In other words, after recognizing the character in our mental lexicon, we can obtain its accurate pronunciation. Therefore, comparing with the LDT, the frequency difference between high- and low-frequency characters would shed light on the role of phonology on recognition, which could account for the larger frequency effect in the naming task in Chinese.

Owing to the task demands of processing phonology in naming, a regularity effect was observed for low-frequency characters. As compared with regular characters, the slower responses to the low-frequency irregular characters and non-phonograms might give rise to the longer RTs, which could explain the larger frequency effect in naming. In contrast, there was no regularity effect observed in the LDT. Taken together, the process of lexical access may involve no pre-lexical phonological processing and the retrieval of phonology may occur after access to the mental lexicon has completed in the naming task.

In the test stimuli, if the combination of two characters makes sense and hence can be used in our language expression, it is defined as a real word. In contrast, if the combination has no meaning and does not have a corresponding lexical representation, it is a pseudo-word. The manner of recognizing words is different between the LDT and the naming task. The LDT requires a participant to judge whether the two-character word on the screen is a real word or a pseudo one. The participant would need to recognize both characters and their combination within a word before they can make an accurate judgment. However, the naming task requires the participant to pronounce the word. As soon as the participant begins to pronounce the leading character within a word, the voice-key is activated and naming latency is recorded. As a consequence, it is possible that the participant is able to start naming a multi-character word from the leading character without a complete recognition of the whole word.

In Chinese word recognition, the frequency effect was found in both the LDT and naming tasks, suggesting that both tasks could capture the process of word recognition. As compared with the naming task, the larger frequency effect in the LDT implied a more complete lexical access. The frequency effect in the naming task was diluted by a possible sub-word character pronunciation process. The smaller frequency effect observed in the naming task could be explained as follows. Due to the task demands, the participant may begin to make the oral response starting from according to the leading character before identifying the whole word. The process in the naming task is similar to that with using English words as stimuli. Taking the dual-route mixed model[9] for reference, naming a Chinese word may also involve two processes: the lexicon driven process and the character naming process. The latter process may attenuate the frequency effect to some extent in Chinese word recognition.

Moreover, compared with the LDT, higher accuracy was found for low-frequency words in the naming task. This finding further supports that pronouncing a Chinese word may not rely on the process of lexical access necessarily. The participant could only pronounce characters without identifying the whole two-character word to fulfill the task requirement.

The critical steps within the protocol are recruiting sufficient participants and selecting proper stimuli. To compare frequency effects, the type of tasks is between-subject variables, and to eliminate possible confounds, there will be a need for considerable amounts of participants. Researchers should carefully control for the characteristics of the participants which may influence the performance in the tasks, for example, literacy ability, amount of recognized characters, educational background. Moreover, to select suitable stimuli, researchers need to manipulate key variables of the characters or words (*e.g.*, occurrence frequency) and control other irrelevant variables to reduce confounds (*e.g.*, number of strokes, positions of radicals, character/word structure) in a strict way. Following those rules, seeking as many stimuli in each condition as possible is highly recommended, which will improve the internal validity of the experiments.

One potential criticism of adopting both the two tasks is that it requires more time, related resource, and participants, as compared with merely undertaking one type of task. However, in light of the complex psycholinguistic characteristics in stimuli and limited amounts of items in each condition, there is much uncertainty for psycholinguistic research to draw a clear conclusion. Researchers need to adopt more than one experiment task and repeat the experiments using different batches of participants several times, which surely costs more effort but it is worthy. The ultimate goal is to reach an inference with high reliability and validity from observations in experiments.

The widely used way for researchers to conduct psycholinguistic experiments is choosing a classical and reliable task (*e.g.*, LDT, naming, semantic judgment task) to investigate the cognitive mechanism of lexical access. The novel approach introduced in this paper is to adopt both the LDT and the naming task meanwhile in one study. According to the unique task demands of each task, comparing the results between the two tasks can further understand mental processes such as before, within, or after the identification phrase. It provides researchers a more valuable inspiration to a full picture of the character/word recognition, which cannot be shown in research with using only one type of task.

In a recently published paper about the neighborhood size effect in Chinese word recognition[11], researchers also adopt both the LDT and the naming task. Some of their observations are in line with those in Experiment 2, suggesting robust effectiveness of the present experimental approach.

It is worth expecting the applications of the approach to more various issues, which may contribute to the theoretical construction in the research fields. Combining it with neuro-cognitive techniques can serve the purpose of exploring the neural correlates underlying the related cognitive processes.

Disclosures

The authors have nothing to disclose.

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