Temporal Modulation of Lexical Access: Unpacking Word Frequency Effects in Advanced L2 Chinese Processing

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Abstract. This study utilized a lexical decision task to investigate the impact of varying time intervals (500 ms, 750 ms, 1000 ms) on lexical processing in advanced Chinese L2 learners, with particular attention to the interaction between time interval and word frequency. The results indicated that a 750 ms interval optimised performance, facilitating both higher accuracy and rapid responses, especially for high-frequency words. In contrast, the 500 ms interval, while reducing reaction time, posed greater challenges for mid- and low-frequency words as well as non-words, without significantly improving accuracy. These findings contribute theoretical insights for L2 vocabulary instruction and assessment, and offer practical implications for the design of more effective learning tools.

Keywords: Word Frequency Effect; Time Interval Effect; Advanced L2 Chinese Learners; Lexical Processing

1 Introduction

The word frequency effect, whereby high-frequency words are processed more rapidly and accurately than low-frequency words (Warren, 2013), has been well-established across a range of domains, including reading, auditory processing, and visual word recognition (Mei et al., 2024; Shain, 2024). Among L2 learners, this effect may be moderated by factors such as cognitive load, proficiency level, and specific task demands (Pashler, 1994; Perfetti & Hart, 2002; Diependaele et al., 2013). The present study explores the processing of words across different frequency bands by advanced Chinese L2 learners under varying time intervals and interference conditions, examining their interaction and offering insights for more effective language learning strategies.

The initial research conducted by Forster and Chambers (1973) revealed that high-frequency words are identified more rapidly than low-frequency words, thereby establishing the foundation for subsequent studies on the word frequency effect. Andrews (1989) further extended these findings by showing that both word frequency

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and neighbourhood effects influence reaction time, thus providing further support for Forster's conclusions. Two prominent models have been proposed to account for this effect. The first is the Logogen Model (Morton, 1969), which suggests that high-frequency words possess lower activation thresholds. The second is the Interactive Activation Model (McClelland & Rumelhart, 1981), which posits that word recognition occurs across multiple levels, with high-frequency words holding a processing advantage. Furthermore, low-frequency words, which require greater cognitive resources, may be subject to differential impact by short interstimulus intervals (ISIs), either facilitating or inhibiting their activation (Lowder, Choi, & Gordon, 2013).

The role of ISI and Stimulus Onset Asynchrony (SOA) is key in lexical processing. Telford (1931) identified that shorter intervals between stimuli slow reaction time to the second stimulus, known as the psychological refractory period. White, Palmer, and Boynton (2020) showed that shorter ISIs limit word processing, particularly for semantically related words. However, Lam et al. (2015) found consistent priming effects across ISI conditions. Predictive Coding theory (Spratling, 2016) suggests the brain predicts upcoming words to speed up processing. Snell et al. (2018) showed that bilinguals activate translation equivalents across languages when words are rapidly presented (≤ 200 ms), indicating parallel processing. While most research focuses on native speakers, this study uses lexical decision tasks to examine how advanced Chinese L2 learners process vocabulary under different ISIs, measuring reaction time and accuracy [1-2]. It also assesses how language switching affects their recognition of semantically related words under varying ISIs. The study aims to:

A. Examine the word frequency effect in high and low frequency word processing.

B. Explore the impact of different ISI intervals on lexical decisions.

2 Methodology

Participants: The participants were 18 advanced Chinese L2 learners with HSK 5 to HSK 6 proficiency levels.

Materials and Procedures: Materials were from the Modern Chinese Frequency Dictionary, including six sets of high-frequency (e.g., "Classroom, school, teacher") and mid- to low-frequency words (e.g., "Classroom, Library, Lecturer"), with an average stroke count of 16-18. Images for the naming task were generated by ChatGPT 4.0 [3].

Words were presented individually in random order, with ISIs of 500ms, 750ms, and 1000ms to observe residual activation. Participants also named 10 images in their native language before proceeding to the third lexical decision task, similar to the first [4].

Data analysis: This study used a Mixed-Effects Linear Model (mixedlm) to analyze the impact of time interval, word frequency, and test rounds on reaction time, with subject ID as a random effect. A Generalized Linear Model (GLM) with a binomial distribution was used for accuracy analysis, considering the same factors.

3 The Impact of Time Interval, Word Frequency, and Test Rounds on Reaction Time

This study found that a 500ms interval reduced reaction time by 161.736ms (P=0.007), and a 750ms interval by 200.396ms (P=0.001), showing strong residual activation effects. Reaction times for low- to mid-frequency words increased by 262.986ms (P=0.000) and non-words by 349.806ms (P=0.000) compared to high-frequency words [5-6]. The interaction analysis showed more pronounced word frequency effects at shorter intervals (500ms, 750ms), with the effect weakening at 1000ms, as shown in Table 1.

Table 1. Summary of the Impact of Time Interval, Word Frequency, and Test Rounds on Reaction Time

Term	Coef.	Std.Err.	z	P>|z|	[0.025	0.975]
Intercept	1059.778	68.826	15.398	0	924.882	1194.674
Time[T.500ms]	-161.736	59.991	-2.696	0.007	-279.315	-44.157
Time[T.750ms]	-200.396	59.991	-3.34	0.001	-317.975	-82.817
Frequency[T.LMF]	262.986	59.991	4.384	0	145.407	380.565
Frequency[T.NW]	349.806	59.991	5.831	0	232.226	467.385
Test_Rounds[T.Second]	-261.542	59.991	-4.36	0	-379.121	-143.962
Time[T.500ms]:Frequency[T.LMF]	-14.618	84.839	-0.172	0.863	-180.9	151.664
Time[T.750ms]:Frequency[T.LMF]	58.035	84.839	0.684	0.494	-108.247	224.317
Time[T.500ms]:Frequency[T.NW]	55.889	84.839	0.659	0.51	-110.393	222.171
Time[T.750ms]:Frequency[T.NW]	220.889	84.839	2.604	0.009	54.607	387.171
Time[T.500ms]:Test_Rounds[T.Second]	394.889	84.839	4.655	0	228.607	561.171
Time[T.750ms]:Test_Rounds[T.Second]	275.771	84.839	3.251	0.001	109.489	442.053
Frequency[T.LMF]:Test_Rounds[T.Second]	219.681	84.839	2.589	0.01	53.398	385.963
Frequency[T.NW]:Test_Rounds[T.Second]	201.479	84.839	2.375	0.018	35.197	367.761
Time[T.500ms]:Frequency[T.LMF]:Test_Rounds[T.Second]	-477.569	119.981	-3.98	0	-712.728	-242.411
Time[T.750ms]:Frequency[T.LMF]:Test_Rounds[T.Second]	-267.493	119.981	-2.229	0.026	-502.652	-32.335
Time[T.500ms]:Frequency[T.NW]:Test_Rounds[T.Second]	-268.257	119.981	-2.236	0.025	-503.415	-33.098
Time[T.750ms]:Frequency[T.NW]:Test_Rounds[T.Second]	-360.729	119.981	-3.007	0.003	-595.888	-125.571
Group Var	52875.796	42.719				

4 The Impact of Time Interval, Word Frequency, and Test Rounds on Accuracy in Advanced L2 Chinese Learners

This study examined the effect of different time intervals (500ms, 750ms, 1000ms) on the accuracy (ACC) of advanced Chinese L2 learners in a lexical processing task. At 500ms, accuracy increased slightly by 0.8223 (P=0.083) but was not significant [7]. At 750ms, accuracy significantly improved by 2.1109 (P=0.006), indicating the most substantial effect compared to the 1000ms baseline.

For word frequency, accuracy dropped significantly for low- to mid-frequency words by -1.5205 (P=0.000) and even more for non-words, decreasing by -2.2351 (P=0.000). Interaction analysis showed that at 750ms, accuracy improved for low- and non-frequency words but remained lower than for high-frequency words [8-9]. The results suggest the 750ms interval had the most pronounced effect, while differences at 1000ms were more stable, as shown in Table 2 [10-11].

Table 2. Effects of Time Interval, Word Frequency, and Test Rounds on Accuracy in Advanced L2 Chinese Learners

Term	Coef.	Std.Err	z	P>|z|	[0.025	0.975]
Intercept	2.1518	0.273	7.888	0	1.617	2.686
Time[T.500ms]	0.8223	0.474	1.735	0.083	-0.107	1.751
Time[T.750ms]	2.1109	0.763	2.768	0.006	0.616	3.605
Frequency[T.LMF]	-1.5205	0.324	-4.691	0	-2.156	-0.885
Frequency[T.NW]	-2.2351	0.32	-6.99	0	-2.862	-1.608
Test_Rounds[T.Second]	1.1733	0.531	2.211	0.027	0.133	2.213
Time[T.500ms]:Frequency[T.LMF]	0.1067	0.551	0.194	0.847	-0.973	1.187
Time[T.750ms]:Frequency[T.LMF]	-1.4072	0.809	-1.74	0.082	-2.992	-0.178
Time[T.500ms]:Frequency[T.NW]	-0.0458	0.533	-0.086	0.932	-1.09	0.998
Time[T.750ms]:Frequency[T.NW]	-1.6047	0.799	-2.008	0.045	-3.171	-0.039
Time[T.500ms]:Test_Rounds[T.Second]	-2.1364	0.706	-3.026	0.002	-3.52	-0.753
Time[T.750ms]:Test_Rounds[T.Second]	-2.7279	0.952	-2.864	0.004	-4.595	-0.861
Frequency[T.LMF]:Test_Rounds[T.Second]	-1.4106	0.584	-2.415	0.016	-2.555	-0.266
Frequency[T.NW]:Test_Rounds[T.Second]	-1.3979	0.581	-2.405	0.016	-2.537	-0.259
Time[T.500ms]:Frequency[T.LMF]:Test_Rounds[T.Second]	2.7594	0.818	3.371	0.001	1.155	4.364
Time[T.750ms]:Frequency[T.LMF]:Test_Rounds[T.Second]	2.9653	1.025	2.893	0.004	0.956	4.974
Time[T.500ms]:Frequency[T.NW]:Test_Rounds[T.Second]	1.779	0.783	2.271	0.023	0.243	3.315
Time[T.750ms]:Frequency[T.NW]:Test_Rounds[T.Second]	2.6409	1.01	2.614	0.009	0.661	4.621

5 Conclusions

This study examined how different time intervals (500ms, 750ms, 1000ms) affect advanced Chinese L2 learners' lexical processing, focusing on the interaction between word frequency and time. Results showed that shorter intervals, especially 500ms, significantly reduced reaction times for high-frequency words, suggesting residual activation helps speed up familiar word processing. However, low-frequency words and non-words faced increased cognitive load, leading to slower responses. The 750ms interval offered the best balance, improving both speed and accuracy, particularly for high-frequency words, while low-frequency words still posed challenges. At 1000ms, the processing speed plateaued, and the word frequency effect weakened, aligning with theories that high-frequency words have lower activation thresholds

(Morton, 1969). In summary, 750ms provides the most efficient interval for balancing accuracy and speed in word recognition tasks, especially for high-frequency words, while shorter intervals challenge low-frequency word processing.

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